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HEALTH EFFECTS OF RADIATION EXPOSURE

HEARING

BEFORE THE

COMMITTEE ON LABOR AND HUMAN RESOURCES UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

ON

EXAMINING THE HEALTH EFFECTS OF RADIATION EXPOSURE CAUSED BY OPEN AIR ATOMIC TESTING AND URANIUM MINING

FEBRUARY 8, 1990

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HEALTH EFFECTS OF RADIATION EXPOSURE

THURSDAY, FEBRUARY 8, 1990

U.S. SENATE,
COMMITTEE ON LABOR AND HUMAN RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 11 a.m., in room SD-430, Dirksen Senate Office Building, Senator Orrin Hatch, presiding.

Present: Senators Hatch and Simon.

OPENING STATEMENT OF SENATOR HATCH

Senator HATCH. I think we'll begin.

This hearing is one further step in a longstanding effort by a number of us in the Intermountain West to achieve some measure of justice for two groups of deserving victims. The first are the citizens who lived downwind from the open air atomic testing at the Nevada test site in the Fifties and Sixties. Second are the uranium miners who were unknowingly exposed to harmful doses of ionizing radiation from 1947 to 1971.

Prior efforts to secure appropriate redress in the courts have unfortunately proven unsuccessful. Notably, in 1984, the United States District Court, based on an extensive record, determined that there was negligence on the part of the government with respect to the exposure resulting from the atomic blasts at the Nevada test site.

The court made awards to 10 of the 24 plaintiffs in test cases. However, in 1987, this decision was reversed by a panel of the 10th Circuit Court of Appeals. This reversal was not based on the particular merits of the cases, but on that court's conclusion that the exception to the Federal Tort Claims Act relieved the government of liability. Significantly, however, one judge on the panel specifically emphasized the great sympathy the court had for the individual cancer victims who had alone borne the costs of the government's choices. He concluded, however, that "their plight is a matter for Congress".

Circuit Judge McKay was correct—the plight of these injured and patriotic Americans is a matter for Congress, and there is clear precedent for Congressional action in this regard.

In 1985, for example, Congress acted on the Marshall Islands Compact, a historic vote to remedy the damages suffered by foreign citizens who happened to live on the islands downwind of the atomic testing that occurred in the Pacific testing area.

Then again, more recently, the 100th Congress overwhelming approved Public Law 100–321, to provide assistance to veterans exposed to the harmful effects of atomic radiation while in the line of duty.

In my view, the case for compensating the downwinders and uranium miners is in many respects even more compelling. The downwinders, for example, were patriotic Americans—men, women and children who lived in the arid environs of the Nevada test site. The level of their exposure was in large part due to the government's unconscionable failure to properly care for or warn those victims. If they had been told of the dangers of fallout straight out, they would have still supported their government, but they would have also gotten indoors and escaped the blasts and the aftermath of the blasts; they would have kept their children indoors; they would have washed themselves and their clothes more often during the period of danger resulting from the fallout; they would have tried to avoid contamination in the food that they provided their families. But the record is clear. Adequate warnings were not given, and neither was information concerning adequate precautions that could have minimized the risks of exposure.

The same is true for uranium miners, whose plight was equally compelling. From 1947 through 1971, the Federal government during that time controlled all aspects of the production of nuclear fuel. Uranium was mined for this purpose. The government had adequate warning of the hazards involved in uranium mining, and yet these miners, many of whom were Native Americans, were sent into inadequately ventilated mines with virtually no instruction regarding the dangers of ionizing radiation.

So we are here once again this morning. This Senate Committee and others have held hearings in the past aimed at determining the medical consequences of radiation exposure and examining how liability should be assessed for the harm suffered.

We resume this effort today by calling upon a number of noted experts to share their views and findings regarding the health effects of radiation exposure. It is absolutely clear to me, and I trust it will be to the other Senators, that a legislative solution needs to be found and enacted in order to provide a reasonable remedy for these brave people.

Last fall, this committee and the Senate voted on some important changes in the vaccine compensation law to make the processing of those cases more efficient and equitable. After careful reflection on this matter, I think that the vaccine law provides us with an excellent model to follow in the cases of downwinders and uranium miners.

Briefly, under such a proposal, a special master of the United States Court of Claims would be given exclusive jurisdiction to hear claims and render judgments for money damages to be paid from a $100 million trust fund.

Some will undoubtedly complain about the costs that might be associated with helping these victims. I hope and trust that my colleagues will conclude that this cost is outweighed by the need to right this grievous wrong.

I'd also like to note that I have the assurances of the chairman of this committee, Senator Kennedy, that this legislation will be

marked up and reported by the full committee on February 28. I want to thank Senator Kennedy for his sincere concern and for his help and cooperation in moving this essential legislation forward and for his cooperation in holding this day of hearings.

We have had so many days of hearings that I think this ought to be the culmination.

I look forward to the testimony this morning and trust that it will add considerably to the already substantial record in this matter. But we have no illusions. We know that there are a few strong opponents of this legislation in the Senate who have announced that they won't let it pass under any circumstances. We'll just have to see what happens, but we'll do our very best, and I think the testimony to be given this day will help to establish the case even better than it has been—although it is hard for me to see how we could make a much more overwhelming case than we have.

With that, we are very pleased to put the statement of Senator Edward Kennedy, the chairman of this committee, into the record.

[The prepared statement of Senator Kennedy follows:]

PREPARED STATEMENT OF SENATOR KENNEDY

Senator KENNEDY. Since 1978, the Senate Committee on Labor and Human Resources has sought to create a fair and just means to compensate victims of atmospheric nuclear testing. Despite years of effort and several hearings, we have yet to pass legislation to establish a program that adequately compensates victims and accurately assigns blame for causing disease.

We have known about the long-term consequences of radiation exposure and the negligence of our government in admitting the serious health impact of this exposure for a very long time. Because of that negligence, part of an American generation now faces illness, disability and premature death.

Fallout emitted during above-ground nuclear tests in Nevada several years ago exposed citizens who lived down-wind in Nevada, Utah and Arizona to excessive amounts of radiation. As a result of this exposure, there has been a significant increase in the incidence of cancer in those communities down-wind from the testing site. This situation is not unlike other instances of radiation exposure to large populations.

Excess cases of leukemia, lymphoma, myeloma, and cancer of the loung, thyroid, breast, esophagus, stomach and colon have been observed among the survivors of Hiroshima and Nagasaki. Estimates of excess cancer deaths in the Soviet Union and Western Europe from the Chernobyl accident arnage from 8,000 to 28,000. As many as 300 infants born in the area of Chernobyl may suffer from mental retardation as a result of the accident. Increased rates of cancer, infant and total mortality have been observed in Pennsylvania counties down-wind from Three Mile Island in the years following this accidental release of radiation. And many have suggested that increased rates of cancer and other illness in the vicinity of nuclear power plants in New England may be attributed to low-level radiation exposure.

I believe the fate of those exposed to nuclear radiation is a public health tragedy in which our government has proven insensitive to

the needs of its own people. That tragedy demands that we overcome large obstacles and overlook time-honored defense in order to achieve a just result.

To be fair and equitable, a compensation program must provide prompt and certain relief for readily identifiable and attributable illness and death. Legal presumptions are the linchpin of equity and therefore the issue of greatest concern.

We have been successful in establishing compensation programs for veterans exposed to radiation, and for children who suffer vaccine related injuries. I look forward to working with Senator Hatch and other colleagues on the Committee on Labor and Human Resources, to devise a fair and equitable system of compensation for those exposed to radiation from atmospheric nuclear testing.

Senator HATCH. We are equally pleased to have my colleague from the House and friend, Wayne Owens, who has handled this matter in the House and has done a terrific job in doing so. We are not through yet, but Wayne deserves a lot of credit if this bill ever passes; I hope that it will, and I hope that the Senate won't be where it bogs down, but I suspect that if it does, it will be here.

So we are happy to have you and welcome you to the committee, Congressman Owens, and we look forward to taking your testimony at this time.

STATEMENT OF HON. WAYNE OWENS, A REPRESENTATIVE IN CONGRESS, FROM THE STATE OF UTAH

Dr. OWENS. Thank you, Mr. Chairman. I am delighted to be here with you this morning and address through you, Chairman Kennedy, my old boss for many years when I used to work over here in the Senate, and others on the committee this morning.

I can report to you the overwhelming, in fact unanimous, support yesterday of the House Administrative Law Subcommittee of the House Judiciary Committee when they considered, marked up and reported unanimously the counterpart House bill for the radiation victims bill which is before you today.

Senator HATCH. We congratulate you for that.

Dr. OWENS. It is a big day.

Senator HATCH. We tried to work the House side ourselves, but I think you deserve a lot of credit for getting that done.

Dr. OWENS. Well, based on what you said about some problems over here, maybe I can return that favor.

Senator HATCH. Well, I hope you can.

Dr. OWENS. I want to say how grateful I am, Mr. Chairman, for the leadership you have shown over the years on this issue. Many years ago, as you well know, in fact nearly 12 years ago, I began with Stewart Udall, as a lawyer working on this fallout victims case, a case which we took to the Federal court and which, as you know, Mr. Chairman, we won, only to be reversed at the 10th Circuit by the Court of Appeals on the Sovereign Immunity Doctrine, an abuse of the Federal Tort Claims Act by that interpretation, in my view, and an abuse which I will add, we are attempting to change by statute in the House.

We have proven this radiation case in court. These good people of southern Utah and northern Arizona, as you well know, Mr.

Chairman, were abused many, many, many years ago and are still awaiting some recognition of government sorrow or regret for the abuses heaped upon them from the radiation which came from the atomic bomb testing of the Fifties or Sixties.

The uranium miner victim case—an interesting sidelight that came up yesterday and is perhaps not well-understood, though I know it is by you—the reason that we have sought $100,000 compensation for the uranium miner victims as opposed to the fallout victims is the total clear, absolute proof available on the record that the government knew in 1950—the Public Health Service warning the operating company of those uranium mines in Marysvale—the dirtiest uranium mines in the country and perhaps the world, Mr. Chairman—the Public Health Service warning the Atomic Energy Commission and the company in 1950 that unless those mines were properly ventilated that at least three-fourths of those men would die from lung cancers. And the government allowed that abuse to happen knowingly, and the company allowed it to happen. Settlement of this case has been made against the company, but the government case, of course, was dismissed out of court on the same premise on which they dismissed the fallout case.

So before you is, of course, both the case of the fallout victims for compensation and the case of the uranium miner victims as well.

It certainly seems appropriate, Mr. Chairman, that one of these last remnants of the Cold War which is the reason, of course, that these victims suffered be cleared up now, as in Eastern Europe, historic things are happening to bring about an end to the Cold War between our country and the Eastern Bloc nations.

So I am grateful that the committee is taking the time to hear it and I will not take further time of the committee to explain the bill because you have done very well, and of course, you and Chairman Kennedy, Chairman Kennedy having helped us many years on this bill—know that very well.

And again, my deep appreciation for your move and your leadership over the years in trying to rectify this great wrong.

I am confident that the House, the full House Judiciary Committee, will report out within the next month this bill to the House floor and that we will pass it I think sometime in March. Our timing is obviously pretty much parallel to yours. We don't see serious problems on the House side. So we are very hopeful and confident that this great wrong can be rectified, and I want you to know that it has been an honor and a pleasure to work with you so closely on this and with the rest of the members of the Utah Delegation—Senator Garn, Congressmen Hansen and Nielson have been supportive of this act.

Some of these good witnesses that you have before you this morning I have known for 12 years, and Dr. Archer especially is so credible on this issue of the uranium mine victims. I am glad you have them here, and I wish you well on your hearings.

Thank you very much, Senator.

Senator HATCH. Thank you very much, Congressman Owens.

I appreciate your statement and appreciate your hard work on this issue.

If you would like, I'd love to have you come up and sit and participate in the hearing.

Dr. OWENS. Unfortunately I have another obligation.

Senator HATCH. Well, we are glad that you were able to take time out of your busy schedule and come over and chat with us today, and we appreciate your testimony. It is very influential.

Dr. OWENS. Thank you.

Senator HATCH. Why don't we have all three of you come up next—Dr. Heath, Dr. Lyon and Dr. Archer.

We'll start with you, Dr. Heath. I appreciate your appearing before the committee today on behalf of the American Cancer Society to bring us up-to-date on a very important recent study, the BIER V report, regarding the effects of radiation exposure.

So we'll hear from you first, and then I will introduce Dr. Lyon and then Dr. Archer.

STATEMENTS OF DR. CLARK HEATH, PROFESSOR OF COMMUNITY HEALTH, DIVISION OF PUBLIC HEALTH, EMORY UNIVERSITY SCHOOL OF MEDICINE, ATLANTA, GA, AND VICE PRESIDENT FOR EPIDEMIOLOGY AND STATISTICS, AMERICAN CANCER SOCIETY; DR. JOSEPH L. LYON, ASSOCIATE PROFESSOR, DEPARTMENT OF FAMILY AND PREVENTIVE MEDICINE, UNIVERSITY OF UTAH SCHOOL OF MEDICINE, SALT LAKE CITY, UT; AND DR. VICTOR E. ARCHER, CLINICAL PROFESSOR OF OCCUPATIONAL MEDICINE, UNIVERSITY OF UTAH SCHOOL OF MEDICINE, SALT LAKE CITY, UT

Dr. HEATH. Thank you, Mr. Chairman.

Senator HATCH. If I could interrupt you for just a second, I am supposed to be on the Floor right now as the Floor manager for the Hate Crimes Bill, which is a very important bill. So we would appreciate it if you could summarize, and if it is possible for you to stay within the 5-minute range, that would be great, but I don't want to cut you off; this is important testimony. Go ahead.

Dr. HEATH. I had not planned at all to read my testimony; it has been submitted to the committee, and I believe you have that before you.

Senator HATCH. Without objection, we'll put the full statements of all of you in the record as though fully delivered.

Dr. HEATH. My task in appearing before the committee today is to give you at least an overview of the BIER V report. That is a committee of the National Academy of Sciences which has been meeting over the last several years to reassess the relationship of radiation to health effects. And their report particularly emphasizes the relationship to cancer causation.

The report was recently released just before Christmas and has been very well-received in the scientific community and I think provides us with a very important step forward in understanding how radiation relates to cancer in particular.

Unfortunately we don't have any direct measure, as you know, of cancer causation by radiation because the latency period is so long between the time exposure occurs and the time the cancer develops, and we have no biologic markers yet because our knowledge of how that process occurs is not as far-advanced as we would like it

to be. So we rely on epidemiologic data, and the BIER report which I have here basically works with epidemiologic data from two sources to re-work, re-estimate to the best of our current knowledge what the radiation effects are with respect to cancer.

The two population areas that they deal with are of course the survivors in Japan from the two nuclear blasts and then groups of patients who have been exposed over the years to therapeutic doses of radiation in the course of treatment for medical conditions.

They also have used new mathematical models which improved computer technologies enable them to do, and we have a larger body of epidemiologic data on which to draw these new estimates.

So from this work, which is really quite significant, this committee has come up with a set of estimates which in fact indicate that a particular dose of radiation in a population probably produces three to four times as much cancer as we had thought from our previous estimates, which were largely based on a similar BIER committee which met 10 years ago and issued its report in 1980, I believe.

Now, it is important to recognize in considering this increase in risk estimate which the BIER V report presents that there are inevitable statistical uncertainties in this, and they have to do with the numbers involved in the observations in Japan and the medical therapeutic situation. Those uncertainties are considerable. They work in both directions. The estimate may be too high; it may be too low on the basis of these statistical considerations.

On the whole, for a dose of 10 rem—I'll use the old nomenclature; they have changed the terminology about radiation dose in the meantime, which is like changing miles to kilometers, and we can't keep track of how those dose measurements go—but for a dose of 10 rem, it was considered a single dose to a population of 100,000, that that would account for perhaps 3 or 4 percent of all the cancers that might occur in that population.

So even with this new dose estimate, you still have for a fairly sizable low dose, 10 rem, a fairly low proportion of all cancers that occur in a population attributed to it. So it is not that this new dose estimate enables us to at low doses say this group of cancers are caused by radiation, but it does change the scenario somewhat.

What will happen with these new, revised estimates of radiation cancer risk? It is hard to say. For radiation exposure guidelines with respect to workers, it is likely that there will be some reconsideration of current guidelines and resetting of standards.

I think in the interest of time, I will refer you to the written statement for more details on this rather difficult and abstract topic, and I would be glad to answer any questions that you might have.

[The prepared statement of Dr. Heath follows:]

PREPARED STATEMENT OF DR. CLARK HEATH

Mr. Chairman and Members of the Subcommittee, I am Dr. Clark Heath, Vice President for Epidemiology and Statistics of the American Cancer Society. It is my pleasure to be with you this morning to discuss the cause and effect of radiation and cancer. While the American Cancer Society has no position on S. 841, the "Radiation Exposure Compensation Act," we believe that it is important to provide medical and scientific information.

In 1986, the National Research Council formed a committee to reassess the effects on human health of exposure to low levels of ionizing radiation. The report of that committee, known as BIER V (the fifth report of NRC committees, over the years, regarding various aspects of the biologic effects of ionizing radiation), was released in December 1989. The report reviews present scientific knowledge regarding a wide range of health outcomes (cancer, genetic effects and mental retardation), but with particular emphasis on cancer. My testimony today will be confined to the report's observations concerning cancer.

The major conclusion of the BIER V committee was that risk of human cancer after low level exposures to x-rays and gamma rays is probably three to four times higher than earlier estimates, notably the 1980 report of the BIER III committee. To appreciate both the importance and the

limitations of this new cancer risk estimate one needs to understand: 1) the nature of information upon which risk estimates of low-exposure radiation health effects are necessarily based; 2) the particular reasons which underlie the present risk estimate change; 3) the size and precision of the new estimate for different cancer sites; and 4) the possible future impact which the BIER V report may have on health protection practices.

1. The basis for low-exposure risk estimates

Since we do not yet know exactly how the biologic changes induced by ionizing radiation can lead eventually to cancer, we still are not able directly to identify particular cases of radiation-caused cancer. Yet it is obvious that cancer does result from exposure to ionizing radiation. That knowledge comes from epidemiologic observations made in human populations which have received relatively high radiation doses. Since even at very high doses, cancer appears in only a rather small proportion of exposed persons, populations in which it has been possible to make useful epidemiologic observations have been limited to ones involving fairly large numbers of persons. These populations, in effect, are 1) Japanese survivors of the 1945 atomic bomb explosions (about 7,600 persons for whom dose estimates have been established) and 2) various groups of patients who have received relatively high doses of

ionising radiation as treatment for a variety of medical conditions.

Even with such large populations, however, observed now over several decades, it is not statistically possible to detect increased frequencies of cancer at exposure levels much lower than about 0.1 Gy (10 rad). It, therefore, is necessary to estimate risks of cancer at lower exposure levels by extrapolating, or projecting downward, from the observed risks at higher levels. That process of extrapolation requires the use of mathematical models which predict the relation of cancer risk to radiation dose at differing dose levels. Past risk estimates have used models which predicted less cancer per radiation dose unit at low levels than at high levels (linear quadratic models). One significant change made by the BIER V report was, for cancers other than leukemia, to use a simple linear model (the same cancer risk per dose unit at low and high levels) as a basis for risk estimation. This choice was prompted by the manner in which existing human data (Japanese atom bomb survivors and patients receiving radiation therapy) appear to fit an array of different possible mathematical modes.

2) <u>The reasons for the BIER V risk estimation change</u>

Three factors underlie the BIER V cancer risk estimation change. One is the change in mathematical modes, just mentioned, for extrapolating from high to low dose

effects. This shift particularly affected risk estimates for cancers other than leukemia (where the linear quadratic model still seemed to fit best with available data), but it had some influence at all cancer sites.

A second factor was the availability of more epidemiologic data than had been available before both for Japanese atom bomb survivors and for patients receiving radiation therapy. In each instance, several years of further population follow-up have obviously yielded increasing numbers of cancer cases as these populations grow older, a fact which lends increasing statistical power to the data at hand.

The third factor was the development in 1986 of new radiation dose estimates for the cohort of Japanese atom bomb survivors. These new estimates resulted from new data regarding the physical nature of bomb radiations at Hiroshima and Nagasaki, especially the relative absence of neutron emissions previously thought to be an important source of radiation from the Hiroshima bombing. These revised dose reconstructions were lower than those previously estimated (1965), and hence the observed cancer mortality patterns were associated with a lower radiation dose than previously believed.

3. <u>The size and precision of the BIER V risk estimates</u>

The BIER V report expresses its new estimates of cancer risk in terms of three different x-ray/gamma ray exposure scenarios: 1) a single instantaneous exposure of 0.1 Sv (10 rem): 2) a lifetime continuous exposure of 1 mSv (100 mrem) per year; and 3) a continuous exposure to 0.01 Sv (1 rem) per year from age 18 through 64. The second of these scenarios approximates a general population exposure setting and the third an occupational setting. Table 1 shows the number of cases of cancer (leukemia and other cancers) estimated to result from the first exposure scenario (see the BIER V report, pages 172-173).

TABLE 1

Excess cancer mortality estimates:
lifetime risks per 100,000 persons
(general population, all ages) exposed to a single
instantaneous dose of 0.1 Sv (10 rem) of ionizing radiation

	Male			Female		
	All cancers	Leukemia	Other cancers	All cancers	Leukemia	Other cancers
Total cases expected	20,510	760	19,750	16,150	610	15,540
Cases caused by radiation	770	110	660	810	80	730
95% confidence limits	540-1,240	50-280	420-1,040	630-1,160	30-190	550-1,020
Percent of expected cases	3.7	15	3.3	5	14	4.7

In this table it is evident that over a lifetime about 20 percent of all people eventually will die of cancer and that of those cases about four percent can be attributed to the 0.1 Sv radiation exposure in question. That proportion, of course, is

subject to a certain degree of statistical uncertainty as governed by the population sizes and cancer case numbers involved in the epidemiologic observations on which the calculations are based. Hence the 3.7 percent value for males, within its 95 percent confidence range, might as correctly from a statistical view point be expressed as 2.6 percent or 6.0 percent (540 or 1,240 cases among 20,510 total). Such percents vary among different cancer sites according to degrees of tissue radiosensitivity, leukemia representing the most sensitive site (15 percent or 110 of 760 cases).

Table 2 compares the BIER V cancer risk estimates with those offered in 1980 by the BIER III committee (using the latter report's relative risk model) for both the 0.15 Sv single exposure and the 1 mSv per year lifetime exposure scenarios (see the BIER V report, page 176).

TABLE 2

		Male		Female	
		Leukemia	Other Cancers	Leukemia	Other Cancers
Single exposure 0.1 Sv	BIER III	27.4	192	18.6	213
	BIER V	110	660	80	730
	Ratio V/III	4.0	3.4	4.3	3.4
Lifetime exposure 1 m Sv per year	BIER III	15.9	92.9	12.1	118
	BIER V	70	450	60	540
	Ratio V/III	4.4	4.8	5.0	4.6

From these comparisons, one can appreciate that the new BIER V risk estimates exceed those of BIER III by about a 3 to 4 fold margin, for the various reasons explained above.

4) The possible impact of the BIER V report

The BIER V committee was charged only with reassessing the health effects of exposure to low levels of ionizing radiation and not with recommending how those new risk estimates should be applied with respect to standards of radiation protection. It seems likely, however, that groups such as the National Council on Radiation Protection and Measurements will now consider these estimates as a possible reason for readjusting such standards as exposure limits for workers exposed to radiation.

Overall, the new BIER V risk estimates are best viewed as reflecting not a radical departure from earlier estimates, but the result of much improved and expanded information regarding human radiation risk in terms of both dose measurements and epidemiologic data. They also reflect our improved capacity, with computer assistance, to develop appropriate statistical models for use in risk estimation. Uncertainties still remain, of course, particularly with respect to the eventual cancer risks for persons exposed early in life. As further epidemiologic data develop over time, further risk estimate adjustments may well be needed again in the future.

Mr. Chairman and Members of the Committee, I will be happy to answer any questions.

Senator HATCH. Dr. Heath, I think I will ask questions after each bit of testimony. Could you explain how these new risk estimates developed for low-level exposure to x-rays and gamma rays relate to the total exposure situations where ionizing radiation of other sorts may also be involved?

Dr. HEATH. Yes. These estimates are specifically expressed in terms of x-rays and gamma rays and not in terms of other forms of radiation, but there are ways to translate the effects, to equilibrate the numbers, so that one can work out a total does in a particular exposure situation.

It is important that using these estimates I am sure one take into account all the circumstances that are involved in a particular exposure situation but particularly the dose situation, the type of radiation involved, and then see how the answers work out. The response to radiation is very much dependent on age, on sex, on the time of observation that is involved, so it is hard to take these simple numbers that we have presented in this testimony and apply them to any one situation. It takes examination of the particular circumstance of the particular radiation situation to develop that risk estimate.

Senator HATCH. How might future epidemiologic data regarding cancer risk for persons exposed as children, for instance, in the followup of the Japanese populations, for instance, be expected to affect future risk estimates?

Dr. HEATH. The report makes it quite clear that this is just another step in our knowledge of what radiation does in terms of cancer.

The Japanese experience, for instance, we have not completed our observations there. The people who were exposed as young children in Japan are now just entering the decades when cancer becomes a health problem, the fifties and the sixties. So it will be important to reevaluate this risk estimate in terms particularly of those people as they start to experience cancer in the years to come, in the next 15 or 20 years, which is particularly critical because the data thus far suggests that at least for some cancer sites, exposure at a young age may involve greater risk in later adult rate than if they were exposed at an older age.

Senator HATCH. Well, we will be interested in your continual study of this matter. We think your report is very important here today, and we appreciate your being here.

Dr. HEATH. Thank you.

Senator HATCH. Dr. Lyon, welcome back. I recall that you testified before the committee on this very same issue back in 1981, almost 9 years ago, and that is a blatant reminder of how very long we have been working on trying to secure some compensation for these citizens of Utah and neighboring States suffering the effects of radiation exposure from nuclear testing.

So I look forward to having you bring us up-to-date on your work and the work of others in this area, and if you could summarize your statement, it will be included in the record in its entirety.

Dr. LYON. Thank you, Senator.

Very briefly, since the time I last testified, additional studies of leukemia have been completed, basically using the data that we used and the information we published in 1979. The last study was

done by a statistician at the National Cancer Institute, Dr. Charles Land. These studies have all come up with estimates of risk for leukemia approximately similar to the ones we found—that is, about a threefold increased risk of leukemia in children who were in the area. Now, individual dosimetry, as you know, has been a problem throughout this entire area, but those estimates are the best estimates we now have to work with, and no one has been able to disagree with them.

The thyroid study that you are aware was done in the mid-1960's has been reopened, and as you are aware, we began a large study at the University of Utah in 1982. That study is now in its final report-writing stage. We will have information available for the funding agency and the general public within the next year.

Basically, we have examined all leukemias in the State of Utah. We have attempted to reconstruct doses on each individual using the information provided by the Department of Energy for both leukemia and for thyroid cancers and other thyroid diseases in the State. We have also tracked down a substantial part of the schoolchildren who were examined in 1965 to 1968 and reexamined them and also obtained enough information to assign them individual doses of radiation. As these reports are finished, I would hope that they would be included as part of the hearing record.

Senator HATCH. Thank you. We will be happy to include them.

Dr. LYON. That's all I have.

[The prepared statement of Dr. Lyon follows:]

PREPARED STATEMENT OF DR. JOSEPH L. LYON

Good morning, I am Dr Joseph L. Lyon, an Associate Professor in the Department of Family and Preventive Medicine at the University of Utah. I am trained in epidemiology, and have done research on the causes of different types of cancer in human populations. I am appearing before this committee to report on research that I carried out in 1977-1978 regarding the effects of atomic fallout from the Nevada Test Site and subsequent increase in leukemia in citizens of Utah. I will also comment on other epidemiologic studies of this same problem, and about additional research at the University of Utah, now nearing completion, which also addresses this issue.

The U.S. Government carried out over 100 above ground tests of nuclear weapons at the Nevada Test Site (NTS) between 1951 and 1958. These tests produced radioactive products which were carried by prevailing winds into the areas surrounding the NTS. The extent of the exposure of the citizens of these communities to weapons generated radiation was not known at the time, but there was concern over the long term health effects of exposure to radioactivity from weapons generated fallout among individuals living in these areas.

Exposure to radiation was known to increase the risk of leukemia and other forms of cancer. The point at issue was (and still is) whether the amount of weapons generated radiation any citizen was exposed to was sufficient to increase his risk of cancer.

Because of the public concern over the adverse effects of fallout, three studies were conducted between 1961-1968. The first was a study by the Centers for Disease Control (then the Center for Communicable Diseases) in Atlanta, Georgia. This study investigated so called "clusters" of leukemia in several rural towns in Iron and Kane Counties in Utah which had received radiation exposure from the NTS. These "clusters" were comprised of leukemia cases which had occurred in two small towns in the late 1950's and early 1960's. The studies focused on the possibly of a viral infection increasing the risk of leukemia in the citizens living in these communities. No effort was made to determine if the leukemia cases had been exposed to NTS radiation before the onset of illess, or if the leukemia rates in these communities was increased compared to communities with lower levels of exposure to fallout. No evidence for a common infectious agent for any of the cases was found.

The second study was performed under the auspices of the U.S. Public Health Service (USPHS) and conducted by Mr. Edward Weiss, a statistician in their employ. The mortality rates for all types of leukemia were estimated for the two Utah counties closest to the NTS, Washington and Iron, for the years 1950-1964. A comparison of these rates to leukemia rates of Brooklyn, New York was made. The rate for all forms of leukemia was 1.46 times higher in Washington County, Utah compared to Brooklyn, New York. Those who died from leukemia under age 19 had rates that were 3.29 times higher than Brooklyn, New York[1]. Weiss

wrote up these conclusions for publication in a scientific journal, and submitted the paper to the USPHS for approval before submitting it to a scientific journal. After consultation with other scientists in the Atomic Energy Commission (now the U.S. Department of Energy) his superiors decided not to publish the findings, or pursue further studies of leukemia in this area. (The unpublished manuscript was located by a Freedom of Information request by a reporter for the Washington Post and its findings published in the Post in January, 1979.)

The third study was motivated by concern over the exposure of children to fission generated radioactive iodines. It was known in the 1950's that radioiodines could enter the human body through ingestion of fresh milk, and that some of these, principally Iodine-131, had a long enough half-life to reach significant concentrations in the thyroid gland. Children, because of their smaller gland size and higher metabolic rate, were believed to incorporate more iodine into their thyroid gland than adults. It was suspected that this exposure could increase the risk of thyroid neoplasia. For this reason the USPHS directed Mr Weiss to organize a study of thyroid disease in Utah.

This study had several components. A review of all hospital admissions for any type of thyroid surgery for those under age 30 was done. There was evidence of an increase in thyroid cancer among individuals who might have been exposed to radioiodines from the NTS[2].

An additional study of thyroid disease was also conducted, and included all children who were in grades 5 through 12 in 1965 in the schools of Washington County, Utah and Graham County, Arizona. These children would have been between ages 0 to 5 when NTS testing was begun. The children in Utah were believed to have been exposed to substantial amounts of radioiodines from the NTS fallout,

and the children in Arizona served as an "unexposed" control group. In 1966 school children from Lincoln County, Nevada were added to the study. This county is due west of Washington County, Utah and was believed to also have received significant amounts of NTS fallout. There were 4819 children who had been examined, at the study's conclusion in 1968. The investigators reported that the occurrence of thyroid disease, especially thyroid nodules, was about the same between the two geographic areas[3]. The study was criticized because it lacked any information about the exposure of individuals to radioiodines, and the length of time after exposure was believed to be too short for a radiation effect to be seen.

In 1977 a group at the University of Utah, of which I was a member, became interested in the issue because of a newspaper report of higher than expected leukemia death rates in Washington and Iron Counties in Utah between 1950-1969. We devised a study to address this problem. We chose to study childhood leukemia because children were known to be more sensitive to radiation than adults, and leukemia was known to increase shortly after radiation exposure.

We included all leukemia deaths ages 0-14 in Utah between 1944-1975. We used the period before and after exposure (1944-1951 and 1959-1975) as a control period and compared this rate to that which occurred in children born during the exposure period of 1952-1958. No information was available on individual exposure to NTS fallout, so we divided the state into high exposure and low exposure areas. Northern Utah was classified as a low exposure area compared to southern Utah.

We found the leukemia death rate to be 2.44 times higher for those dying from leukemia in the high exposure area, who were born during the exposure

period, compared to those dying in the same area who were born before or after exposure. We further subdivided the high exposure area into those counties closest to the Nevada Test Site and those further away from the NTS. We found the leukemia death rate was 3.4 times higher for those dying in counties closest to the NTS, compared to the same areas before and after testing[4,5].

Our study was criticized because of the lack of individual exposure estimates with the possible result that some of the individuals dying of leukemia might not have been exposed to fallout. A question was also raised about the possibility of over-reporting of leukemia, and under-reporting of other types of cancers in children[6] A subsequent study was carried out by the study critics, using leukemia deaths for 1950-1978 for the State of Utah. They reported that leukemia mortality was 1.5 times higher, but, since this was not statistically significant, they concluded that no effect of fallout from the NTS was present[7].

In 1984 Johnson published a study which found leukemia rates to 3.28 times higher in selected communities which were believed to have been heavily exposed to fallout[8]. This same study also reported excess risk for several other types of cancer. We criticized this study because none of the cancers had been confirmed from hospital records and/or death certificates[9]. There was also evidence that the individuals included in the study had been selected to substantially overstate the number of cancers that might have occurred.

In 1987 a group, working with Land at the NCI, published a study in which they attempted to replicate the findings from the 1984 Johnson study using death certificates, a more reliable source of cancer diagnoses[10]. They reported an excess of leukemia deaths, but not of other types of cancer. For all leukemias

combined they reported the rates in the exposed group to be 1.45 times higher than the so-call unexposed counties. For those dying of leukemia under age 19, the rates were 2.84 times greater than the unexposed counties used as a control group. This latter finding was close to the rate ratios (RR's) from the Weiss study (RR = 3.29) and our study (RR = 3.40) though the definitions of exposure and time of followup differed.

The studies by Weiss[1], Land et al[10], and our group[4,5], all used the death certificates from the counties in southwestern Utah. Each study used a slightly different definition of what constituted exposure to the NTS fallout, and all have concluded that there was an increase in the leukemia mortality rate among those who died under age 20 who were likely to have been exposed to NTS fallout. The smallest geographic unit for which exposure was available was the county. All three studies included Washington County, the county believed to have highest exposure to NTS fallout of all Utah Counties. Only the study by Machado and Land[10], examined the question of excess risk from other types of cancer, and concluded there was no evidence for an excess risk for any other type of cancer.

ADDITIONAL STUDIES

In 1982 the University of Utah undertook a study to better address the shortcomings of the above studies. This study focused on leukemia and thyroid disease, and had as its main goal the estimation of individual doses of radiation to NTS fallout. This study is nearing completion. All data collection has been completed, and the data are being analyzed. The final reports of findings will be submitted to the funding agency, the National Cancer Institute, within the next year.

The issue of excess risk from leukemia from exposure to NTS fallout was addressed by carrying out a case-control study. All cases of leukemia who died between 1952-1981, and who were members of the Church of Jesus Christ of Latter-day Saints (commonly called Mormons or LDS and referred to as LDS hereafter), were included in this study. This yielded 1177 cases of leukemia. A control group of 5330 individuals, who were also members of the LDS church and were known to be dead, was selected. The LDS church records were used to reconstruct a lifetime residential history for these individuals. Exposures to radiation from NTS fallout were obtained from the database provided by the U.S. Department of Energy. Using each subject's residential history, and the data provided by the Department of Energy, an individual radiation dose from NTS fallout was assigned. The second part of this study examined thyroid disease in those who had been originally examined in 1965-1970 by the USPHS. An attempt was made to relocate all 4819 subjects. Over 90% were found. All those still living in Utah, Nevada or Arizona were eligible to be re-examined. We were able to re-examine 2829 of these individuals. We also interviewed the parents of all these subjects and determined each subject's milk drinking habits from birth until age 18. This interview also provided us with information about each individual's sources of milk during the time of exposure to NTS fallout. Using this information, and exposure estimates provided by the Department of Energy, a dose of radiation to the thyroid gland was estimated for each individual.

The study conducted by the University of Utah, and now nearing completion, is the most comprehensive examination of the possible adverse health effects of fallout from the NTS undertaken. It includes one of the largest dose reconstruction efforts ever undertaken any where in the world.

Senator HATCH. Let me ask you a few questions.

Could you describe generally the extent to which your research in this area has been delayed and complicated by governmental failure to monitor the fallout exposure levels experienced by not just our citizens in Utah, but in neighboring States as well?

Dr. LYON. We started out with virtually no dose estimates, and it has taken several years for the government to actually find data necessary to make dose estimates. Fortunately, some of the unique record sources in the State of Utah meant that we were at least able to track people's residential history, and the fact that this group of schoolchildren exposed to the radioiodines were young enough that their parents were still alive permitted us to obtain interview information about the children's milk consumption patterns. This has added several years and several million dollars of cost to the study because of the failure to have this dosimetry information available.

Senator HATCH. Well, based on your extensive study of this particular issue, is it your opinion that if precautions which were not taken had been taken, the risks of exposure would have been minimized?

Dr. LYON. Yes. Judge Jenkins in his opinion pointed out that virtually all of the precautions were quite simple—either diverting fresh milk for a few days to other sources such as butter or cottage cheese or cheese production, and simply having people stay in for a period of time—none of these precautions were taken, and unfortunately this meant the exposures came up into levels that could be considered dangerous for human health.

Senator HATCH. It is my understanding that when you testified before the District Court back in the early 1980's in the case of *Allen v. United States*, you disclosed what the trial judge termed "substantial evidence of increased incidence of leukemia, particularly among children" in the offsite area. You testified at that trial that in your opinion the data reflected a probably of between 59 and 71 percent that the leukemia resulted from exposure to fallout radiation.

You also testified, I believe, that there was a 240 to 340 percent increased incidence of childhood leukemia in Utah counties closest to the identified patterns of significant fallout when compared to expected rates.

Dr. LYON. That is correct.

Senator HATCH. All of that is correct.

Dr. LYON. Yes. Those numbers simply derive from the numbers I stated in the first of my testimony, that have since been confirmed by Dr. Land at NCI—that is, the rate of leukemia in those areas that were known to be heavily exposed is around three times higher than the unexposed or low-exposure groups, and everything else simply derives from those numbers.

Senator HATCH. Is there any other explanation for it, other than the——

Dr. LYON. None has been presented to date.

Senator HATCH. All right. Dr. Lyon, as I recall, when you testified before this very same committee back in 1981, you expressed considerable frustration in the lack of funding and delays in securing funding for studies on the health effects of radiation exposure.

Well, here we are at least 7 years later, and I know you expect your current studies to be completed shortly. But can you explain, Dr. Lyon, why this has all taken so long and whether or not this delay is all justified?

Dr. LYON. Well, to answer the last question first, I think whether it is justified or not is a judgment others would have to make; we can't. The main reasons for delay are the difficulties in obtaining enough information to assign individual doses. Once we got into the study, it became clear that the effort to assign individual doses for somewhere close to 8,000 individuals, probably one of the largest dosimetry efforts every taken anywhere in the world, would take substantially longer and cost substantially more than anyone from either University of Utah or in the Federal government had anticipated. And we felt that this was worth it for the benefit of the citizens of the State, and so we went, if you will, the substantially more expensive and longer route.

Senator HATCH. Thank you.

Finally let me just add that we look forward to the results of your ongoing studies that you have described here this morning. I think those are going to be very important. I would, without objection, hold the record open so that we can place those studies in the record that we are making on this matter, certainly if they are completed within the anticipated time frame, because I think many, many people will be interested in what you conclude after, really, the seminal work that you have done on this issue. So I myself can hardly wait until you have those studies completed.

Dr. LYON. Thank you.

Senator HATCH. Thank you.

Dr. Archer, it is a very great pleasure to have you with us today to discuss radiation exposure of uranium miners in the Fifties and Sixties. I know personally that your work in this area as the principal investigator for the Public Health Service's epidemiology study of miners from 1956 to 1979 and with the University of Utah Medical School since 1979 makes you uniquely qualified to speak on this particular issue. So we are very pleased to have you here.

I would like to include in the record the impressive list of your publications, many of which deal with the uranium miner issue, so without objection we will include those in the record.

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Senator HATCH. Now, Dr. Archer, if you could summarize your testimony for us this morning, we will include your complete statement in the record, and then I will have some questions for you.

Dr. ARCHER. Thank you, Mr. Chairman.

The lung cancer among underground miners was first noticed in Central European miners who were working on a large ore body in the mountains which separate East Germany from Czechoslovakia. Their disease during the middle ages was called "mountain sickness". It was in 1879 that that mountain sickness was shown to be lung cancer.

When the United States started mining uranium in the 1940's, we were well aware of this history in Europe and that they had made some measurements and shown high radiation in those Central European mines and had also shown that 40 to 70 percent of the miners died of lung cancer.

So we knew this information when our mining started in the 1940's, so at that time, Mr. Holaday of the Public Health Services started to make measurements in our uranium mines to see if they were comparable to the European measurements. Dr. Bale at the University of Rochester started calculating radiation dose, and he found that the dosage calculations depended primarily on the short half-life radon daughters or radon progeny, which were created in the air from radon and tended to attach themselves to dust particles in the air. So when a man breathed this dust, essentially carrying the radon progeny piggyback, the dose from these radon progeny on the dust gave the lining of the man's tracheal-bronchial tract about 20 times the dose that would come directly from radon itself.

So Holaday and associates then rather quickly developed a practical method to measure the radon decay products in mines and demonstrated that those levels could be controlled by ventilation.

At that point in 1952 and 1953, the Public Health Service proposed to the involved States and to the Atomic Energy Commission that they set a limit on amounts of radon daughters to which the men could be exposed. They set one Work Level as the limit and defined it carefully, and they also proposed that the Atomic Energy Commission pay a bit more for the uranium ore and call it a ventilation allowance to induce the mine operators to ventilate.

Well, at that time—this was 1953—all the parties rejected the proposal. The Atomic Energy Commission disclaimed responsibility because they felt they had no responsibility for radiation safety until the ore was delivered to the mills. The mine operators rejected it because it would cost too much. The States reflected the mine operators' opinions pretty much, but they also pointed out that they had no radiation expertise and no money for extra inspectors. In addition, all the people excused their inaction by saying that there was no proof that the radon was a hazard in U.S. uranium mines.

At this point it became apparent to the Public Health Service that in order to stimulate regulations, it would be necessary to demonstrate essentially with body counts that our radiation here was just as bad as it was in Europe. And because of the long latent period between initial exposure and development of cancer, this meant we had to set up a long-term study.

So the physicians of the Public Health Service then started examining uranium miners periodically and putting them into our cohort of miners. I joined this effort in 1956.

The first indications in our study of excess deaths came in about 1960 from a preliminary analysis so that we rather quickly reported this to the State officials and tried to urge them to reduce the levels so that the States were convinced then and did make some initial efforts starting in 1960, but their efforts were apparently only half-hearted, so that the radiation levels in the uranium mines slowly fell between 1960 and 1970.

In 1967, we had a rather more thorough analysis, and at this time it became apparent that that one Work Level was probably too high as a permanent limit, so it was reduced by approximately one-third. However, even this lower level was not fully enforced until about 1971, when the new Mine Safety and Health Administration started enforcing it.

These continuing studies of uranium miners have disclosed that the lung cancer rate among smoking uranium miners is about five times greater than among similar smokers in the general population; among nonsmoking miners, it is about ten times higher than similar nonsmokers in the general population.

During the early 1970's, results of laboratory experiments became available. These were studies on rats and dogs which were done in France and the United States. These studies confirmed that exposures to high levels of radon and radon progeny resulted in high lung cancer rates and that the dose response curves in these animals was very similar to what we had found it to be among humans. So with these animal experiments confirming our human studies, there was no longer any question or any doubt that the radiation in the mines was responsible for the high lung cancer rate.

Of the several thousand men who worked in uranium mines after 1950 or so, there have been between 500 and 600 of them who have died of lung cancer. About half of them who worked before 1960 have now died, so that I would expect that in the future there will be another 500 or 600 lung cancers among this group.

There has also been a large excess of deaths among uranium miners from other lung diseases, which we group together as nonmalignant respiratory diseases, NMRD. This includes pulmonary fibrosis, radiation pneumonitis, emphysema, silicosis, chronic bronchitis, chronic obstructive lung disease, and cor pulmonale.

We have shown that the radiation in the mines does contribute to this group of deaths. We cannot assign radiation to any particular one of these diseases, but it seems to contribute somewhat to all of them. We also know that there are other contributors to these diseases, such as silica dust, cigarette smoking, chronic infections, and we are unable to really separate them out as to causation.

There have been between 400 and 500 deaths so far from these NMRD groups, so that we would expect there would be a similar number among the uranium miners in the future.

I have been involved in a number of workers' compensation cases in about five States in the West with uranium miners, and I have been frequently asked to determine whether the particular lung cancer was more likely or not caused by the radiation in the mines.

For nonsmokers, this is quite easy if their radiation exposure has been above 100 Work Level Months, and among the nonmining population, the rate of lung cancer among nonsmokers is so extremely low. For heavy cigarette smokers, however, this is a little more difficult. Usually above 800 Work Level Months, it is more likely than not that the lung cancer is due to the radiation. At Work Level Months below 300, then it is more often than not that cigarette smoking turns out to be the more important cause.

This is not to say that lung cancer does not occur among miners who have had less than 300 Work Level Months, that it does not occur as a result of radiation, but in groups of heavy smokers with less than 300 Work Level Months, we have found that smoking does cause a higher fraction of the cases than the radiation does. But we cannot make that sort of division for the NMRD cases, so that I would recommend that if any thresholds for exposure are used that they would be set the same as for the lung cancers.

Thank you.

[The prepared statement of Dr. Archer follows:]

PREPARED STATEMENT OF DR. VICTOR E. ARCHER

I would like to start by giving a brief history of the uranium miner problem, summarize the animal studies and human epidemiological studies that have been done, and then give my ideas as to how this research on radon and lung cancer can be applied to the problems of compensation.

Before the birth of Christ, the Romans were obtaining lead and silver from mines in the central mountains of Europe. They had huge ore deposits which have survived nearly continual mining from that time to the present. They have been worked for lead, silver, cobalt, uranium and radium. It was noticed that many of the miners died rather young of a disease called "mountain sickness". This disease was shown, in 1879, to be mostly lung cancer. High levels of radiation from radon were found in these mines in the 1920's. This radiation was proposed as the cause of the excess lung cancers, which were found to be 40 to 70% of all deaths.

A controlled study of mice exposed to radon was started in Germany, but was interrupted by World War II. It was not completed until 1959, when it reportedly found radon-induced lung cancers in the mice. In the meantime, Dr. Egon Lorenz, a noted radiobiologist reviewed the European data in 1944 and calculated lung dosage from radon, then declared that the European lung cancers could not have resulted from radon because the radiation dose to lung tissue was too low. He failed to consider the radiation dose from the decay products of radon attached to dust.

After the U.S. began mining uranium in the late 1940's, Dr. William Bale, at the University of Rochester, reexamined the radiation dose problem, and in 1949, came to the conclusion the radiation dose to miners was very high. The radioactive decay scheme of uranium by then was well known. It started with uranium-238, which has a half-life of over 4 trillion years. It was known that the chain decayed with 14 distinct steps to stable lead, creating a new element at each of the steps. All but one of these elements were metals. These metals would tend to stay in the ore where they were formed. The one exception is radon. It occurs near the middle of the chain and is a gas which does not react chemically with other atoms. It tends to diffuse out of the rock or ore where it is created, and tends to collect in any open space--such as the air of a mine or cave. Radon has a four day half-life, so its levels can build up quite high. The next four decay steps create isotopes of lead, bismuth and polonium, which have a collective half-life of about 30 minutes. These four are referred to as radon progeny or radon daughters. What Dr. Bale found was that in a mine atmosphere, radon would concentrate and create these four rapidly decaying daughter products. These radon progeny, being metals, would quickly become attached to the nearest solid object--which was usually a dust particle in the air. A miner breathing this air would then inhale the dust with radon progeny riding piggy-back on it. The spots at which the dust stopped in the lungs would then be

quickly radiated by the radon progeny. Most of this radiation was from alpha particles, which are more effective in causing cancer than most other types of radiation. Using this new knowledge, Dr. Bale was able to calculate that the lungs of many uranium miners would be exposed to an equivalent of several thousand rems in a few years. This was more than enough to cause high rates of lung cancer.

At about the same time that Dr. Bale calculated the dosages, Duncan Holaday, an industrial hygiene engineer with the U.S. Public Health Service, was sent to Salt Lake City to look into the radon problem in the new uranium mines. He quickly found radon levels in our uranium mines to be as high, and in some cases higher, than those reported earlier in the European mines. Armed with the new knowledge about radon progeny, he and his staff developed a practical field method to measure radon progeny in mines. He then showed that the concentration of radon progeny in mine air could be controlled by ventilation. He and Dr. Bale then proposed a standard which they called a "Working Level" to be applied to mines. It was defined as any combination of radon progeny in one liter of air that results in the release of 1.3×10^5 Mev of potential alpha energy. They did not call it a safe level because their knowledge was insufficient to know whether it was safe or not, but it was a standard which the mine operators could meet and which would definitely reduce the lung cancer risk.

Mr. Holaday, in 1952 and 1953, then proposed to the uranium mining states and to the Atomic Energy Commission that they set and enforce a standard of 1 WL as the maximum permissible exposure limit in mines. He proposed that the AEC pay a bit more for the uranium, so as to compensate the miners for the cost of ventilation, and make it more acceptable to them. His proposal was rejected by the AEC, by the mine operators and by the four uranium mining states. The AEC disclaimed responsibility--they were not responsible for radiation protection until after the ore reached the mills. The mine operators rejected it because it would cost them too much to ventilate. The states reflected the mine operators opinion, pointing out that they had no expertise in radiation safety, and no money for extra mine inspectors. They all justified their inaction by arguing that it was not clear that there was a radiation hazard in U.S. mines. They were unconvinced by high radon levels in mines, by Bales's calculation of dosage, or by the lung cancer experience of miners in central Europe.

It then became apparent to the U.S. Public Health Service that in order to stimulate regulatory agencies into action, it would be necessary to demonstrate with a epidemiological study that radiation in U.S. mines was as much a cancer hazard as it had been in European mines. In 1954, Dr. James Egan of the Public Health Service was asked to set up such a study. He did so, but developed other interests, so I replaced him 1956. The study had two objectives. The first was to determine whether or not lung cancer rates were increased among U.S. uranium miners. The second was to determine, in a scientific manner, the safe

level of radon progeny in mines. We examined and put into the study group a total of 4,138 men. Most of our data has come from 3,346 white miners who worked underground. In order to conduct these examinations, we had to assure mine operators that we would not say anything to alarm the miners or cause disruption of their operations. These men have been followed since then. The radiation exposure of each of them has been calculated in Working Level Months, a term we coined to reflect cumulative exposure to radiation.

We obtained and periodically updated the occupational histories on each of these men. Mr. Holaday collected all the radon progeny measurements made in each of the uranium mines. These measurements were combined with occupational histories to calculate cumulative exposure. This exposure data, used in conjunction with cause of death information from the follow-up efforts, enabled us to periodically calculate the relationship of causes of death to radiation exposure.

By 1960, a preliminary analysis of data from the study of uranium miners indicated that the lung cancers observed would be greater than would be expected from the general population. This data was presented to the states involved, and resulted in some action on their part. Radiation levels in the uranium mines were gradually reduced during the 1960's, faster in some mines than in others.

Further analysis of the uranium miner data lead to the reduction of the proposed standard to 0.3 Working Level in 1967. Good control of exposures, however, was not achieved until about 1971 when the newly created U.S. Mine Safety and Health Administration started enforcing the 4 WLM/year standard.

The continuing studies of U.S. uranium miners have shown that the lung cancer risk among the original study group has been about 5 times higher than for a similar group of non-miners who smoked as much as the miners did. For non-smoking uranium miners, this risk is about 10 times higher than for a similar group of non-miners. These studies have also shown that the dose-response curve for lung cancer from radon progeny is approximately linear for as far as it can be obtained. That is, the risk of lung cancer is directly proportional to the cumulative exposure to radon progeny.

In the 1960's laboratory studies were started in France and the United States in which rats, hamsters and dogs were exposed to known amounts of radon and radon progeny. No lung cancers developed among the hamsters, but many lung cancers were found in the exposed rats and dogs. The rat data showed the same type of dose-response curve as was found among humans. With these animal data, there could no longer by any doubt or question that radon and its progeny were directly responsible for the excess lung cancers found among uranium miners.

There have been between 20,000 and 30,000 different men who have worked in or near U.S. uranium mines. Approximately half of

them worked between 1940 and 1967 and have an increased risk of lung cancer as a result of overexposure to radiation. Between 390 and 410 of the members of the PHS Study Group have developed lung cancer up to the present time. There have been between 100 and 200 more lung cancers among miners not in the study group. Only about half of the study group members have now died, so we would expect to find another 500 to 600 lung cancers among the overexposed miners in the future.

In addition to excess lung cancer among uranium miners, there is also a large excess of deaths from other lung diseases. This is a group which includes silicosis, pulmonary fibrosis, chronic bronchitis, cor pulmonale, and chronic obstructive lung disease. Radiation in the mines almost certainly contributes to these diseases, but silica dust, cigarette smoking and chronic infections also contribute to them. In the PHS Study Group there have been between 315 and 335 such deaths to date. If the ratio of these diseases to lung cancer continues as it has in the past, and miners outside the study group contribute proportionally, then I would estimate that there will be between 400 and 500 more of these deaths among the miners in the future.

Since the publication of our first reports on the U.S. uranium miners, similar studies have been done on other groups of miners around the world. This includes miners of tin, iron, lead, zinc, flourspar, gold, shale-clay, and niobium ores as well as uranium. Most of these studies have confirmed the relationship between radon progeny exposure and lung cancer in man, although they have differed somewhat ina quantitative sense. As a rule, these studies have provided better information at lower exposure levels than was found in the PHS Study Group. The reason is that the PHS group had relatively few people with low exposures.

Many of these studies have reported excess lung cancer among all groups who had cumulative exposures above 100 Working Level Months. WLM is the unit of cumulative exposure to radon progeny usually used because it cannot be accurately translated into more common radiation units such as rad, rem or Sieverts. Some have reported excess lung cancer at levels below 100 WLM. Quite large populations are required for good data at these levels, however, and to date the mining population studied at these levels have been too small to provide reliable data.

Perhaps the best data at the 100-200 WLM exposure levels is given by Samet, et al, 1989a. They found an odds ratio of 1.4 at this level after adjustment for cigarette smoking. These authors used the 1-99 WLM group as the base for determining the risk among the more highly exposed groups, so they were unable to determine whether or not any excess lung cancers were present below 100 WLM.

Because of the lack of firm epidemiological data at exposure levels below 100 WLM, statistical models have been constructed to extrapolate the lifetime risk to much lower levels of exposure. This has been done in order to find levels that are reasonably

safe, and to estimate the risks from radon progeny in residences. There is some uncertainty in results from these models, of course, but at present they appear to give us the best insight into effects at the lower levels. These models have been used by the Environmental Protection Agency, and by expert committees sponsored by the National Council on Radiation Protection and by the National Research Council. Publications by these groups give excellent reviews of the topic as well as giving their estimates of the lung cancer risk at low levels of exposure.

I have provided testimony in over 100 Worker Compensation claims for lung cancer in the states of Arizona, Colorado, New Mexico, Utah and Wyoming. In these cases, I am usually asked to determine whether or not the lung cancer is more likely than not, to have been caused by the radiation exposure. In responding to this question, I regard any exposure above 100 WLM in a nonsmoker to have probably been the cause of the cancer, because of the rarity of lung cancer among non-smokers in the general population, and because the epidemiology studies have demonstrated excess cancers above 100 WLM. Among smokers, the determination is more difficult. I consider the time since start of exposure, the age at cancer development, the cumulative WLM, and the amount of cigarette smoking. For this purpose, I use a graph giving lung cancer risk by WLM and by amount of smoking risk. I then subtract from this a risk value obtained from graphs giving lung cancer risks from different amounts of smoking at different ages. This gives me risk values for radiation and smoking risks separately, so they can then be compared directly above 800 WLM, the probability is nearly always that radiation was more likely the cause than smoking. For heavy smokers, at exposure levels below 300 WLM, cigarette smoking is usually found to give a higher probability of causation. This is not to say that some smokers with less than 300 WLM will never develop radiation-induced cancer, but smoking will probably be responsible for more than half of the lung cancers in these men.

Senator HATCH. Thank you, Doctor.

How early on did you or your colleagues at the Public Health Service become convinced that radiation was a significant problem in the uranium mines?

Dr. ARCHER. They became convinced in about 1949 and 1950.

Senator HATCH. In your opinion was the knowledge base sufficient at that time to justify the use of controls in the mines?

Dr. ARCHER. Probably not in 1949 or 1950, because at that time we didn't have the mechanism worked out for control. But after Mr. Holaday had worked out the method of control, which was primarily ventilation, in 1953, then I would say in 1953 we had an ample knowledge base to start——

Senator HATCH. So from 1953 on, they should have used those types of controls.

Dr. ARCHER. Yes.

Senator HATCH. Were these concerns conveyed to officials at the Public Health Service and the Atomic Energy Commission, and if so what was their response?

Dr. ARCHER. Yes. This information was conveyed to officials in the various States, to the higher officials at Public Health Service, and to the Atomic Energy Commission, and as I indicated in my testimony, the States and the Atomic Energy Commission all declined to participate in any action to lower the levels.

Senator HATCH. So they were unwilling to take immediate action even though they knew that these people were being exposed unfairly.

Dr. ARCHER. Yes. And of course, they had the excuse that the radiation had not yet been proven to be a cause of problems in U.S. mines.

Senator HATCH. And in your view, based on the information available in the early 1950's, from 1953 on, should steps have been taken immediately to ventilate the mines?

Dr. ARCHER. Yes.

Senator HATCH. Do you know what the approximate cost of such ventilation might have been at this time?

Dr. ARCHER. Well, I have never done any calculations of that cost myself, but from the engineers I have talked to, they have told me it might have added something like five cents per pound to the cost——

Senator HATCH. So you are saying a nickel per pound cost when coal was being sold for about $12 per ton would have resolved this problem?

Dr. ARCHER. Yes, yes, that's correct.

Senator HATCH. And nobody suggested that outside of yourself and a few others.

Dr. ARCHER. Yes—some people in the Public Health Service other than myself also suggested it.

Senator HATCH. So they knew about it; they just were not willing to do anything about it.

Dr. ARCHER. Yes.

Senator HATCH. OK. During the period in which this study was being conducted, what kind of levels were the miners exposed to?

Dr. ARCHER. Initially, in the early 1950's and before, the exposure levels were often 10 to 20 times higher than the one Working

Level which Mr. Holaday later proposed. In 1960, the average level was 10 Working Levels, in other words, 10 times the proposal, and then the levels gradually fell after 1960.

Senator HATCH. So you would estimate that these levels exceeded what you would consider to be a safe level by 10 to 20 times.

Dr. ARCHER. Yes; it quite often did, yes.

Senator HATCH. So that's a fair conclusion.

Dr. ARCHER. Yes.

Senator HATCH. That's astounding to me. You would think somebody would have tried to do something about it.

During the period of time in which this study was being conducted and the miners were being monitored, were these miners ever at any time advised what this study concerned?

Dr. ARCHER. Well, right from the beginning, starting in 1949 and 1950, the Public Health Service engineers informed the mine operators, but in order to obtain the mine operators' cooperation to examine miners, we had to promise that we would not say or do anything which would alarm the miners or cause disruption in production. So the Public Health Service could not directly tell the miners about the problem.

It wasn't until 1956 or 1957, I think, when the Public Health Service put out a pamphlet which described the dangers of lung cancer in uranium mines and the inhalation hazard, and we printed several thousand of these pamphlets and distributed them widely actually to the miners themselves.

Senator HATCH. You have referred to the fact that certain scientists at the Public Health Service had serious concerns about exposure levels as early as the late Forties and early Fifties. Are you aware of any instances where employees at the Public Health Service were discouraged from speaking out on this issue publicly?

Dr. ARCHER. Yes. A year or two before I joined the study, Dr. Wilhelm Hupert, who is a well-known cancer epidemiologist at the National Cancer Institute and who is well-acquainted with the Central European studies, visited the early U.S. uranium mines and made some public statements to the effect that he felt that many of the miners would die of lung cancer as a result of their exposures. As a result of this there was considerable protest to the National Cancer Institute, and he was forbidden to travel west of the Mississippi after that.

Senator HATCH. Dr. Archer, have you studied the development of nonmalignant respiratory diseases in uranium miners; have you personally studied that?

Dr. ARCHER. Yes.

Senator HATCH. When did you conduct those studies, and have you published any of those?

Dr. ARCHER. Yes. Our first—probably our best—publication on that was in the mid-1970's, at the New York Academy of Sciences Conference on Cancer and Occupational Diseases.

Senator HATCH. Are there any other specialists who have found similar results to yours?

Dr. ARCHER. There have been none others who have studied it epidemiologically, I don't think, but they have studied it in individual miners, and they have found a reduction in pulmonary function in both Utah mines and in New Mexico.

Senator HATCH. OK. In your opinion, what nonmalignant respiratory diseases did the uranium miners develop as a result of exposure to radiation?

Dr. ARCHER. Well, it is the group of nonmalignant respiratory diseases which I mentioned earlier, primarily pulmonary fibrosis, emphysema, chronic bronchitis, chronic obstructive lung disease and cor pulmonale.

Senator HATCH. And these are the types of radiation diseases that the uranium miners developed as a result of exposure to radiation?

Dr. ARCHER. Well, I can't say that directly because of the contribution of other items to those diseases, but we did show epidemiologically that the exposure to radiation almost certainly contributed to the development of these diseases, and they are much higher among the uranium miners than among nonmining groups.

Senator HATCH. So you are saying there is a high probability that the exposure to radiation contributed to these diseases, these nonmalignant diseases.

Dr. ARCHER. Yes, yes, that's correct.

Senator HATCH. And how would you rate the probability with regard to the contribution toward cancer? Would it also be a high probability?

Dr. ARCHER. Yes, extremely high.

Senator HATCH. To use your terms, almost a certainty?

Dr. ARCHER. Yes.

Senator HATCH. That's a fair statement?

Dr. ARCHER. Among those with higher exposures, yes, it is almost certainly due to the radiation.

Senator HATCH. What in your opinion is the latency period for cancer and these other nonmalignant respiratory diseases and problems?

Dr. ARCHER. It appears to be somewhat longer than the average latent period for lung cancer, although as we are following the people with lung cancer, uranium miners, we are finding that the average latent period keeps getting longer. Initially it was around 15 to 17 years, but it is closer to 25 now.

The latent period for the nonmalignant respiratory diseases is at least as long and perhaps even longer—at least before death.

Senator HATCH. Thank you, Dr. Archer.

Senator Simon.

Senator SIMON. I have no questions, just a very brief statement.

I got involved in this whole question of exposure because of a veteran who was involved in one of the tests in the Anaweetok Islands and discovered that the Veterans' Administration would not acknowledge any relationship between the levels of cancer of those who were exposed and those tests. So I introduced the first legislation along that line, and we finally have passed and have in law at least a little protection now for those veterans.

No one from Illinois is involved in this, but as a result of that, I am very sympathetic to this legislation, and I want to specifically commend Senator Hatch for his leadership in this area. He has been championing his cause, and as one who has learned what this means through the exposure of veterans in the tests and also at Nagasaki, I have come to appreciate the special problems that

people have had downwind here in this country, and I am very pleased to be supportive of Senator Hatch, and I commend you for your leadership.

Senator HATCH. Thank you, Senator Simon. That means a great deal to me.

I think this bill will be marked up in the immediate future, before the end of this month, I hope, and we hope the committee will pass it out, and we are also hopeful that we can then get it to the Floor of the Senate. But if we ever do get this passed, it is going to be in large measure because of the efforts of you people who have been the eminent scientists in this matter. I just want to personally express our appreciation to you, especially for your testimony today. It has been difficult to be hauled back here time after time and be questioned on these matters, but we appreciate the candor and the intelligent testimonies that you have given to us, and we just hope we can resolve this matter in the immediate future.

[Additional statements and material submitted for the record follow:]

PREPARED STATEMENT OF DR. LEON S. GOTTLIEB

Malignant and Non-malignant Lung Disease Among Navajo Uranium Miners

Prior to 1946, the Navajo population was chiefly engaged in agricultural and handicraft activities. Significantly low Indian morbidity and mortality rates for lung cancer were reported during this period. The scarcity of lung cancer was attributed to the salubrious climate, absence of occupational and environmental carcinogens, and the infrequency of cigarette smoking.

Extensive uranium mining in the Four Corners area began about 1946, stimulated by the urgent demand for atomic weaponry. This led to large scale employment of Navajo Indians to work in uranium underground and milling operations.

Between the years 1946 to 1968, underground miners were poorly-protected and exposed to high levels of radiation and rock dust in the mine air. This exposure resulted in a high incidence of lung cancer among this group.

In our Shiprock Navajo clinic for uranium miners, we observed also, in addition to lung cancer, other lung diseases associated with uranium mining and milling. These pulmonary disorders consisted of silicosis and pulmonary fibrosis (scarring of the lung tissue). These conditions were the sequelae of inhaling rock dust and radioactive particles (radon daughters).

Hazardous exposure in uranium mines may lead to malignant or non-malignant lung disease. The malignant type obviously is cancer of the lung; the non-malignant type comprises silicosis of the lung (fibrosis), and radiation pneumonitis (fibrosis).

Silicosis and radiation pneumonitis produce a lung function impairment known as a "restrictive" form of pulmonary impairment (that which affects the air sacs or alveoli). Spirometry is a useful test to demonstrate the degree of lung dysfunction. Chest X-rays and CAT scans are also commonly used to reveal the extent of silicosis and fibrosis.

Other occupational lung diseases (pneumoconioses) that produce a "restrictive" pattern of lung impairment are asbestosis, coal worker's pneumoconiosis, berylliosis (used in alloys and X-ray tubes), etc.

The "restrictive" pattern is typified by a decrease in lung vital capacity and a reduced diffusion capacity. Clinically, patients with pulmonary fibrosis manifest shortness of breath, cyanosis, fatigue, and rales (crackles heard over the lung). Subsequent clinical deterioration may result in cor pulmonale (right heart failure).

While serving at the Navajo Health Center Clinic, we attended many Navajo uranium miners and their families. We also conducted a study at the Shiprock Hospital. In summary, our study (Lung cancer among Navajo uranium miners, Chest 1982; 81:449-52) revealed of a total of 17 patients with lung cancer, 16 were uranium miners. The mean value of cumulative radon exposure was 1139.5 working level months. The time period of the study was 1965 to 1979.

A parallel study to the above was published in 1984 (Samet JM, et al. N Eng J Med 1984; 310:1481-84). This study reported that of 32 Navajo men with lung cancer, 23 had been employed as

uranium miners. Cumulative working level months was calculated with a median of 1207.

The above two studies are commented on in BEIR IV--Health Risks of Radon, 1988 (National Research Council). In BEIR IV p. 289 and p. 436-7, several studies on animals are mentioned relative to radiation fibrosis or pneumonitis resulting from inhalation of uranium compounds.

Incidental Information

I worked at the Navajo Health Center, Shiprock, for two years (1978 to 1980).

At present, I am employed as a clinician at the Santa Cruz County Health Services, in charge of the tuberculosis clinics. I was previously Associate Professor of Medicine (Pulmonary Dept.) at the University of Southern California, School of Medicine in Los Angeles. I was also Chief of Bronchoscopy at the Los Angeles County General Hospital. I have authored two books and many articles on pulmonary disease and medicine. In addition, I am now the medical advisor for Asbestos Victims of America.

Leon J. Goodlad, M.D.

PREPARED STATEMENT OF RAYMOND JOE

Good morning, Mr. Chairman and Subcommittee Members!

My name is Raymond Joe. I worked in many different uranium mines in Arizona, Utah and Colorado. I started working in the mines in Cove, Arizona in 1952 for Kerr McGee. I last worked for Union Carbide in Canon City, Colorado in 1976. I worked a total of 15 years in the mines during this time.

In the days we spent in the mine, we entered "dog holes". There were two shifts. Thirty minutes after the first shift, they blasted dynamite. While it was still smoking from the blasts, they would send us in. The smoke from the dynamite used to get us dizzy and nauseated. Still, they drove us to work in the dust and smoke without any protective clothing, face masks or respirators. We ate our lunch in the mines. We drank water from homemade water fountains in the mines. By the end of the day, we were sent home very sick. This went on year after year.

Safety procedures were never explained in handling explosives, equipment and personal hygiene. The men went home with radioactive clothes. I exposed my home and family. My wife, who washed my clothes, is now having pains like what I had and she is now being diagnosed. We had no idea uranium radiation was dangerous.

I started having problems breathing in 1976. I was diagnosed on March 6, 1976 as having pulmonary silicosis. I was referred back to Shiprock PHS. They gave me medicine, but I wasn't told what it was for or that I was sick because of working in the mines. Since then I get colds alot and very easily. In 1987 I started spitting blood. In December of 1988, I was

diagnosed as having lung cancer. Since then I had to move to Shiprock so I could get treatment twice a month. In January 1989 I was operated on and part of my right lung was removed. In March 1989, I was told there is another growth in the same lung. In July of 1989, they sent my lung x-rays to a cancer center in Albuquerque. They told me the growth is very serious and I only have two years to live.

Of all the people I worked with, only three are still living. Most of the miners who testified before Congress in previous public hearings have now died. How long will these former miners and their families continue to suffer after I pass away?

I am only 56 years old. Because of my illness, I have not been able to work since 1976. In 1976 my three boys and four girls were children and I was the sole provider. We had a hard time and my children never finished high school and therefore are having a hard time finding employment.

In 1976, I applied for workmen's compensation at my last place of employment, which was Colorado. It was very difficult to make my claim. There were many barriers. It took me three years to get it. I was awarded $200 per month, which is what my family has lived on since 1979.

I am in dire need of financial assistance. I live in a substandard home and because my children are not employed, I do not have enough money to even pay my utilities. My family's financial situation will only get worse when I pass away. So I pray for the Radiation Exposure Compensation Act to be passed by Congress so at least I will know that my family will be provided for. Finally, I am making an earnest plea for this bill to be passed on behalf of all Navajo uranium miners victims, survivors, widows and dependents. Thank you.

THE NAVAJO NATION

LEONARD HASKIE
INTERIM CHAIRMAN
THE NAVAJO TRIBAL COUNCIL

IRVING BILLY
INTERIM VICE CHAIRMAN
THE NAVAJO TRIBAL COUNCIL

STATEMENT OF LEONARD HASKIE
INTERIM CHAIRMAN, NAVAJO TRIBAL COUNCIL
TO THE SENATE LABOR COMMITTEE
REGARDING THE RADIATION EXPOSURE COMPENSATION ACT

On behalf of former Navajo uranium miners and/or the surviving families of deceased miners, I am honored to present to the Committee accounts of hardships the Navajo miners are facing as a result of the federal government's negligence. We strongly support the passage of the Radiation Exposure Compensation Act and thank the Committee for considering this legislation on a timely basis.

First, the Navajo Nation extends its gratitude to the United States Government for all the assistance it has given to the Navajo Nation, on a government-to-government basis. As you know, the Navajo Nation is a self-governing political entity that is a dependent sovereign. As expressed in treaties, agreements, statutes, executive orders, administrative orders and judicial pronouncements, a trust relationship exists between the federal government and Indian tribes.

Sadly, the federal government violated its special duty of care to the Navajo uranium miners by failing to warn them and protect them from the hazards of uranium mining. Both the

legislative and executive branches exercised full responsibility over the management of tribal natural resources and health care of miners during the time Navajos worked in the uranium mines on and off of the reservation. Trust responsibilities in the area of health are defined by a comprehensive statutory scheme, the foundation of which is the Navajo Treaty of 1868 and the Snyder Act of 1921. While Navajo miners proudly made a contribution to the national security interests of this country, they now tragically suffer.

By way of background, contained within the Navajo Nation's 25,000 square miles are many valuable mineral resources. One such mineral, uranium ore, was mined from our lands from the Navajo Reservation from the early 1940's to late 1960's. Four (4) large mining districts witnessed these extractions: Cameron, Arizona, Monument Valley, Utah, Shiprock/Lukachukai, New Mexico and the eastern Black Mesa, Arizona. Additionally, Navajo miners worked in numerous uranium mines outside the boundaries of the Navajo Nation within the states of Arizona, New Mexico, Utah and Colorado during the 1970's. The sole purchaser and beneficiary of this radioactive mineral during most of this period was the United States Government.

During this mining era, Navajos encountered their first contacts with the American industrial system. The majority of these miners were not conversant in the English language and had no knowledge of radiation or the health hazards associated with underground uranium mining. While the growth of the nuclear industry brought benefits to the United States Government, tragically, it also resulted in severe health problems and

tremendous suffering to the Navajo uranium workers from that time forth.

Approximately 200 Navajo uranium miners and widow of deceased uranium miners brought suit against the federal government in the 1980's for the injuries they sustained in order to advance the government's nuclear weapons program. The District Court for Arizona ruled in Begay v. United States, 591 F. Supp. 991 (1984), that the court could not consider the case, since the acts and omissions of the federal government officials were shielded from liability by the discretionary function exception to the Federal Tort Claims Act.

The district court, however, found the following facts (the opinion is attached). The United States Public Health Service (PHS), which has the ultimate obligation to execute the federal government's trust responsibility to administer health care for the Navajos, conducted an initial medical/environmental study to assess the dangers of radiation in 1949. This initial PHS study, conducted on the Navajo Nation, indicated the miners were exposed to very high external radiation, radon gas, and high silicate dust containing an undetermined amount of radiation.

The PHS study found that when uranium is mined, the inert gas radon diffuses from the rock. When the miners breathed pure radon, radiation was delivered to the lungs and thereafter the body as it entered the blood stream. Radon gas also breaks down into more deadly radon daughters. These radon daughters quickly attach to solid surfaces, most notably dust. By 1951 PHS realized that when inhaled, the dust particles deposit in the lungs and deliver the greater dose of radiation

to the lungs. By 1951 the PHS and the Atomic Energy Commission (AEC) realized that mechanical ventilation of the mines would remove the radon and the dust-borne radon daughters.

However, in order to proceed with its study, the PHS decided not to tell miners of the potential hazards from radiation for fear that many miners would quit, which would interrupt the production of uranium and inhibit their study of the health effects of radiation. If significant abnormalities were found, the miners were informed and advised to seek treatment at an Indian Health Service hospital; at no time did the PHS undertake the health care of the miners. I find it unconscionable that the federal government, which has a special trust responsibility to care for the health of Native Americans, knowingly sent these miners to their deaths.

By 1959, the PHS study indicated a shocking statistical increase above the number of expected deaths from lung cancer among miners. PHS realized it was watching a group of Navajo uranium miners who were virtually certain to die or suffer disabling lung diseases. Instead of warning them, the PHS continued studying these miners on the pretense that it had insufficient knowledge to establish enforceable maximum permissible standards of radiation exposures. However, the AEC already knew by the late 1940's, of the hazards because physicians from its Health and Safety Laboratory had studied the well-documented cancer consequences in European uranium mines (documented since the late 1920's).

During this mining era, the AEC had the knowledge, funds and power to ensure miners were protected from mining dangers. However, rather than imposing burdens on mining

companies or alarming miners, and potentially slowing production, it kept a shield of secrecy over the uranium mining safety hazards. Therefore, it left the burden of regulation with the states. This is most significant in the case of uranium mines on the Navajo reservation because states had no legal authority to regulate mines on the reservation.

Mine safety standards were not established until the enactment of the Metal and Nonmetallic Mine Safety Act of 1966, which was subsequently repealed by the Federal Mine Safety and Health Act of 1977. Regulations under the original Act, however, were not fully implemented until mid-1971, by which time the damage had already been done to our miners.

Therefore, from the 1940's through mid-1971, Navajo uranium miners were subjected to extremely hazardous working conditions. Navajos were sent into the mines without any protective clothing, face masks or respirators. Because they were not protected, the Navajo workers were continuously exposed to levels of radiation that exceeded by 1,000 times the recommended "allowable" level in the U.S. industries handling radiological contaminants in 1950. Because they did not know of the hazards, they ate their lunches in the mines and drank the water running through the mines. Moreover, they brought radioactive materials out of the mines for purposes such as building materials for constructing their homes. Families were therefore also exposed and similarly injured. Clearly, Navajo uranium miners were needlessly subjected not only to the deadly radon gas and its decay daughters, but to a host of other radiological elements and particles present in the mines.

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Health conditions not previously known to Navajos became predominant among the Navajo miners. Serious respiratory diseases such as fibrosis, pulmonary fibrosis, restrictive lung disease, corpulmonale, silicosis, pneumoconiosis, chronic bronchitis, chronic obstructive pulmonary disease and others became prevalent. Studies show these diseases are caused by exposure to radiation and radioactive dust particles present in the mines. The PHS study, conducted by the federal government, shows that the injuries suffered by uranium miners were caused by the radiation and radioactive dust particles present in the mines. Attached are copies of studies conducted by the former principal investigator for the PHS, Dr. Archer, as well as other studies showing that radiation and radioactive dust particles in the mines caused the cancer and other serious respiratory diseases sustained by uranium miners.

Affected Navajo miners have gone largely uncompensated for injuries they have suffered as a result of the federal government's negligence. Due to their lack of formal education, inability to speak English, and lack of knowledge or access to legal advice regarding occupational disease statutes, few of the miners have been able to obtain any compensatory benefits from State Workers Compensation Laws. For many, the statute of limitations had expired before they knew of the availability of a remedy.

For those who were apprised of it, the remedy has proven inadequate. First, proof requirements are overly restrictive, requiring manifestation of the disease within periods that do not take into account the latency period of

cancer. Second, worker's compensation claims must be filed against the miner's last place of employment, however, many miners do not have records of their last place of employment and when they do, many of these companies are no longer in business and records of their insurance cannot be located. Finally, where miners have recovered under these laws, the level of compensation is a percentage of the earnings while employed. Because these miners worked many years ago, recoveries have been grossly inadequate, in some cases less than $100 per month.

While these victims are also suffering, they would not be compensated for their injuries under the Radiation Exposure Compensation Act. We do not ask for them to be included under the measure, however, we ask you to recognize their plight as well.

Although we do not presently know the exact number of Navajo victims that would be eligible for compensation under the measure, we estimate that it would be in the low hundreds. This figure would depend largely on what diseases would be compensable under the Act. We realize that the federal government is hesitant to create an entitlement program, such as that which was created to compensate coal miners who contracted black lung disease. However, compared to the black lung disease compensation program, the number of radiation exposure victims is small and fixed. Therefore a similar, ongoing entitlement program will not be created.

You, the Congress, are the only ones who can redress the atrocious wrongs committed by the United States government. The district court found in Begay v. United States that the

government was "in need of a constant, uninterrupted and reliable flow of uranium ore from the mines to the mills for urgent national security purposes and as an emerging source in the future for the growing peacetime nuclear energy industry." 591 F. Supp. at 1011-12. Therefore, the decision not to set standards and not to warn the miners of the risks "were the result of conscious policy decisions made at high government levels based on considerations of political and national security feasibility factors." Id. at 1012. The court concluded, "[t]his tragedy of the nuclear age, however, cries for redress. Such relief should be addressed by the Congress as it was in the case of the Texas City explosion following the decision of the Supreme Court in Dalehite v. United States, 346 U.S. 15, 73 S.Ct. 956 (1953)". Id. at 1013.

The Ninth Circuit affirmed the decision, finding that although the Public Health Service knew of the dangers of uranium mining, its decision not to warn of the dangers was clearly within the ambit of the discretionary function. The court stated in its opinion, "[w]e agree with the district court that this is the type of case that cries out for redress, but the courts are not able to give it; Congress is the appropriate source." 768 F. 2d 1059 at 1066.

Both opinions are attached to this testimony. They are instructive because these federal courts found that the federal government knew of the health hazards which caused the miners diseases, however, the law as currently interpreted permits the federal government to escape liability. The federal courts have sent the miners to you, the Congress, to seek justice.

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A compensation program was first proposed by Senator Domenici in the 95th Congress. Hearings were held in 1979 and 1980 before the Senate Judiciary Committee and this Senate Labor and Human Resources Committee. The plight of the miners is a long-standing one; they appeal to you again in 1990.

Mr. Chairman, the Navajo Nation is blessed with many things: a diligent workforce and patriotic United States citizens who have come to the aid of this country through service in the armed forces as well as through their work in the uranium mines. Many Navajos have made the ultimate sacrifice for this country. These Navajo miners believed they were making a contribution to this country. And they did so in the only way they could for there were few other employment opportunities.

Please be mindful of the realities of our Nation. We are, in many respects, a developing nation. The per capita income of our people is approximately $2,400 per year and the unemployment rate is approximately 32 percent. We do not have the resources to compensate and care for these people who have suffered from the negligence of the federal government. Many of these people live in very remote parts of the reservation where there may be no roads, no electricity, no running water, no sanitation facilities, no telephones and few hospitals from which they may receive treatment. Life for former miners with seriously disabling diseases is difficult at best. I appeal to your compassion and sense of justice and ask you to make a compassionate gesture to those whose health was considered secondary to the national security interests of this country.

The Navajo Nation expresses its gratitude for the

leadership and initiative demonstrated by you, Mr. Chairman, Senator Hatch and Representative Wayne Owens in sponsoring H.R. 2372, S. 841 and S. 1994 and conducting hearings on this vital measure.

I would also like to make some specific comments on S. 1994. S. 1994 would create a program that would be administered by United States Claims Court special masters. While the Navajo Nation applauds the Committee's effort to establish a program with a neutral arbiter of claims, it urges the Committee to establish a program that would not force claimants to endure an adversarial proceeding or to prove causation of their injuries. We urge you, the Congress, to make determinations of what injuries the miners sustained as a consequence of their employment in the mines and direct whomever administers the program that such compensable diseases carry irrebuttable presumptions of causation. Administration of the proposed compensation program would be most efficient if the tasks of the special masters were limited to determinations of whether the claimant: worked in a uranium mine during the requisite period, was exposed to the requisite level of radiation, and developed a requisite injury.

The Navajo Nation looks forward to working with you and your staff to assure enactment of this important Act. The Navajo Nation will submit this statement with attached supporting resolutions from the Navajo Tribal Council and several chapters of the Navajo Nation (chapters are local political subdivisions).

Thank you for allowing us the opportunity to submit this statement.

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Original Contributions

Lung Cancer Mortality Among Nonsmoking Uranium Miners Exposed to Radon Daughters

Robert J. Roscoe, MS; Kyle Steenland, PhD; William E. Halperin, MD, MPH; James J. Beaumont, PhD; Richard J. Waxweiler, PhD

Radon daughters, both in the workplace and in the household, are a continuing cause for concern because of the well-documented association between exposure to radon daughters and lung cancer. To estimate the risk of lung cancer mortality among nonsmokers exposed to varying levels of radon daughters, 516 white men who never smoked cigarettes, pipes, or cigars were selected from the US Public Health Service cohort of Colorado Plateau uranium miners and followed up from 1950 through 1984. Age-specific mortality rates for nonsmokers from a study of US veterans were used for comparison. Fourteen deaths from lung cancer were observed among the nonsmoking miners, while 1.1 deaths were expected, yielding a standardized mortality ratio of 12.7 with 95% confidence limits of 8.0 and 20.1. These results confirm that exposure to radon daughters in the absence of cigarette smoking is a potent carcinogen that should be strictly controlled.

(JAMA. 1989;262:629-633)

RADON daughters, both in the workplace and in the household, are a continuing cause for concern because of the well-documented association between exposure to radon daughters and lung cancer.[1-3] Few studies have, however, been able to assess the lung cancer risk from exposure to radon daughters in the absence of cigarette smoking. Studies among Navaho uranium miners, who were predominantly nonsmokers, have demonstrated rate ratios for lung cancer mortality of 4.2[4] and 14.4.[5] Studies of nonsmoking Swedish iron ore[6] and Czech clay shale[7] miners have both shown a rate ratio of 10.0 for mortality from lung cancer. These rate ratios for nonsmokers were generally higher than for cohorts of miners in which smokers and nonsmokers were combined.[8,9]

Various regression modeling techniques have been used to estimate the lung cancer mortality risks for nonsmokers from mixed cohorts of smokers and nonsmokers. Although these techniques are extremely powerful and useful, they require that certain assumptions be true, and the results are sometimes difficult to interpret. To provide additional information regarding the lung cancer mortality risks for nonsmokers exposed to radon daughters, we conducted a straightforward cohort mortality study of US, white, male uranium miners who never smoked cigarettes, pipes, or cigars.

From the Industrywide Studies Branch, Division of Surveillance, Hazard Evaluations, and Field Studies, National Institute for Occupational Safety and Health, Cincinnati, Ohio (Mr Roscoe and Dr Steenland); the Epidemiology Branch, Division of Injury Epidemiology and Control, Center for Environmental Health and Injury Control, Centers for Disease Control, Atlanta, Ga (Dr Waxweiler); Harvard School of Public Health, Boston, Mass (Dr Halperin); and the Division of Occupational and Environmental Medicine, University of California at Davis (Dr Beaumont).

Reprint requests to the National Institute for Occupational Safety and Health, R-15, 4676 Columbia Pkwy, Cincinnati, OH 45226 (Mr Roscoe).

METHODS

Colorado Plateau Study Group

The cohort of white nonsmokers was selected from a larger cohort, also known as the Colorado Plateau study group and as the US Public Health Service (USPHS) uranium miners cohort, that consisted of 3359 white and 779 nonwhite men (total, 4138) who mined uranium on the Colorado Plateau.[10] These totals differ slightly from previous totals reported for this cohort because of racial reclassifications and duplications that have been corrected. To be included in the cohort, miners must have been examined in the USPHS medical surveys conducted between 1950 and 1960 and must have worked at least 1 month underground in a uranium mine by January 1, 1964. (Of the nonsmoking miners, all except 6 completed their first month of mining before the end of 1960.) Although lower before 1964, participation rates in the medical surveys reached approximately 90% of the miners in visited areas in 1957 and 1960.[1] Occupational, medical, and smoking histories were obtained during the examinations and updated during subsequent annual censuses of the miners conducted by the USPHS.

Selection and Verification of Nonsmokers Cohort

We selected for analysis only those white men who had never smoked cigarettes and were thus coded as "nonsmokers" according to their previously

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recorded computer codes from the periodic questionnaires administered by the USPHS between 1950 and 1969.[4] To further verify this information, we reexamined the previously collected questionnaire responses for the 681 miners previously coded as nonsmokers; we did not verify the smoking status of all 4138 cohort members.

Radiation Exposure

The working level months (WLM) of exposure to radon daughters were determined by multiplying the working months (170 hours) spent underground by the working level of the particular mine at that time. One working level is equal to any combination of radon daughters in 1 L of air that results in the ultimate release of 1.3×10^5 MeV of potential α-energy. Lundin et al[5] described the four following methods used to estimate the working level of radon daughters in a given mine during a given year: (1) actual measurements; (2) interpolation or extrapolation in time; (3) geographic area estimation; and (4) estimates before 1950 based on knowledge of ore bodies, ventilation practices, and earliest measurements. A coefficient of variation of 97% in these exposure data and the effect of the errors on relative risk estimation has been evaluated in a previous analysis done by the National Institute for Occupational Safety and Health.[6] For each miner, we had the date he entered the nine exposure categories predetermined by Lundin et al.[5] The nine categories were (1) 0 through 59 WLM, (2) 60 through 119 WLM, (3) 120 through 239 WLM, (4) 240 through 359 WLM, (5) 360 through 599 WLM, (6) 600 through 839 WLM, (7) 840 through 1799 WLM, (8) 1800 through 3719 WLM, and (9) 3720 WLM or more. Because there were only 14 lung cancer deaths among nonsmokers, we collapsed the nine categories into two categories for this analysis. We chose 360 WLM as the midpoint because it is the middle of the nine exposure categories and is close to the median exposure of 296 WLM for this cohort. Exposure to radon daughters from uranium mining ceased for most of the cohort members during the late 1960s.

Vital Status Follow-up

The miners were followed up from the date of their first USPHS medical examination through December 31, 1984, using the records of the Social Security Administration, Internal Revenue Service, National Death Index, and Health Care Financing Administration. Cohort members whose vital status was unknown were considered unavailable for follow-up on the date last observed. Death certificates were obtained for the deceased and coded by a qualified nosologist into the appropriate revision of the *International Classification of Diseases*, using the rules in effect at the time of death. Deceased miners for whom no certificate was located were assumed dead, with the cause of death unknown on the date specified by the reporting agency.

Method of Analysis

The nonsmoking uranium miners cohort was analyzed using a modified life table analysis system developed by the National Institute for Occupational Safety and Health.[7] Although latency and duration of exposure were calculated from the first date of employment underground in a uranium mine, the number of person-years at risk of dying were calculated from the date of the first USPHS medical examination or the date of completion of 1 month of underground uranium mining if that was later. The number of person-years was calculated for specific WLM exposure groups, age groups, calendar periods, and periods after first underground uranium mining. The expected number of deaths was calculated by multiplying the number of person-years by the lung cancer mortality rates from two separate nonsmoking comparison populations. The total number of expected lung cancer deaths was obtained by summing the results over the age groups. The standardized mortality ratios (SMRs) were calculated for lung cancer by dividing the observed number of deaths by the expected number of deaths. Test-based 95% confidence limits (CLs) (two-sided) for the SMR were calculated for cells where there were observed deaths, and 95% confidence limits (Fisher's Exact Test) were calculated for cells where there were no observed deaths.[8] The statistical power to detect various SMRs was determined using one-sided tests[9] because of the a priori belief that SMRs would be elevated.

Veterans' Rates Comparison

The US veterans' mortality rates[10,11] for lung cancer among nonsmoking, white men were used as the primary comparison population (A. Blair, PhD, written communication, February 1987). Because lung cancer rates for nonsmokers have changed little over time[12] and the numbers of observed deaths were small when the veterans' data were divided by calendar periods, we used one set of age-specific rates based on the entire period from 1960 through 1984. The actual age groupings and rates (per 10^5 person-years) used were as follows: 40 through 49 years, 77; 50 through 59 years, 100; 60 through 69 years, 213; 70 through 79 years, 375; and 80 years and older, 706. Since these rates were available for persons who had never smoked cigarettes, pipes, or cigars, we compared them with the rates for uranium miners who had also never smoked tobacco of any kind.

Axelson-Adjusted US Rates Comparison

As a verification of our primary comparison population of nonsmoking veterans, we calculated the rate ratio for lung cancer among non–cigarette-smoking miners using estimated US rates for non–cigarette smokers. To estimate the rates for non–cigarette smokers in the US, white, male population, we adjusted the overall US rate using four age and calendar time-specific adjustments, according to the method proposed by Axelson.[13] First we "decomposed" the known overall US lung cancer rate (I) into a weighted average of rates for non–cigarette smokers, ex-smokers, and smokers to derive an estimate of the rate for non–cigarette smokers (I_n).

$$I = (P_n)(R_n)I_n + (P_x)(R_x)I_n + (P_s)(R_s)I_n + (P_s)(R_s)I_s$$

where I indicates overall mortality from lung cancer in the US, white, male population; P_n, P_x, P_l, and P_s indicate US, white, male population proportions of non–cigarette smokers, ex-smokers, light smokers (20 cigarettes per day or fewer), and heavy smokers (more than 20 cigarettes per day), respectively; R_n, R_x, R_l, and R_s indicate known lung cancer relative risk estimates among non–cigarette smokers, ex-smokers, light smokers, and heavy smokers, respectively, taken from the large prospective study of US veterans. All terms in the equation were known except I_n. We solved for I_n. To adjust for age and calendar time, rates for US non–cigarette smokers were estimated for four age and calendar time combinations (ages 45 through 64 years and 65 years and older, calendar times 1950 through 1974 and 1975 through 1984). Then we used the four estimated rates for US non–cigarette smokers (I_n) to calculate expected deaths in our cohort of miners, after stratifying person-years from the cohort into the same four age and calendar time strata. The numbers of observed and expected deaths for all four strata were summed to derive an overall rate ratio.

The age and calendar time groupings were chosen to provide similar numbers of expected deaths from the cohort of non–cigarette-smoking miners in each

of the four cells to be used in the analysis. The population proportions used in these calculations were taken from 1965 and 1980 National Center for Health Statistics survey data regarding smoking habits among white men in the United States.[9] The years 1965 and 1980 were chosen because they were approximately the midpoints of the two calendar periods—1950 through 1974 and 1975 through 1984. The smoking-specific relative risk estimates for lung cancer used in these calculations were taken from data regarding US veterans divided in the two age groups, 45 through 64 years and 65 years and older.[6] Since pipe and cigar smokers were included in the US proportions of non–cigarette smokers for 1965 and 1980, it was necessary for us to include pipe and cigar smokers in the veterans' risk estimates and in the cohort of non–cigarette-smoking uranium miners for the analysis based on US rates.

RESULTS

Accuracy in Smoking Codes

On review of the periodic questionnaires collected between 1950 and 1969 for the 681 white miners who had been previously computer coded as never having smoked cigarettes (nonsmokers), we found that some had actually smoked cigarettes (13%) and some had smoked pipes or cigars (11%). Those who ever smoked cigarettes were excluded from further analysis. Those who smoked only pipes or cigars were excluded from the analysis that used nonsmoking US veterans (no tobacco of any type) but were included in the second analysis that used estimated US nonsmoking rates. In total, 76% (516/681) reported never having smoked tobacco of any kind, and 87% (593/681) reported never having smoked cigarettes. We corrected all miscoding, including 3 persons with unknown smoking status.

Table 1.—Vital Status of White, Nonsmoking, Uranium Miners, With Follow-up Through 1984

Vital Status	No. (%) of Miners
Alive	387 (75)
Deceased	126 (24)
Certificate obtained	124 (98)
Certificate not obtained*	2 (0.02)
Unknown†	3 (0.01)
Total	516 (100)

*Includes one foreign death for whom no appropriate death certificate can be obtained.
†Persons with unknown vital status had their person-years at risk accumulated only until their last date observed.

Cohort Status

The 516 white nonsmokers had the following characteristics: mean year of birth, 1923; mean year first employed, 1952; mean age first employed, 29 years; mean time in underground uranium mining, 52 months; mean exposure to radon daughters, 720 WLM (median, 296 WLM); and mean rate of exposure to radon daughters, 16 WLM per month (median, 10 WLM/mo). The mean time since first employment in uranium mining until either death or the end of the study was 28 years; the mean time since last employment was 21 years. The mean age at the end of the study for the live cohort members was 56 years. Follow-up of the cohort through December 31, 1984, resulted in only 3 persons with unknown vital status and the identification of 126 deaths (Table 1). Fourteen deaths from lung cancer were found; characteristics of the 14 persons are reported in Table 2.

Lung Cancer: Veterans' Rates Comparison

When the number of observed deaths from lung cancer among the 516 nonsmoking uranium miners was compared with the expected number of deaths derived from the lung cancer mortality rates among white, male, nonsmoking US veterans, the SMR was 12.7 (95% CL, 6.0 and 20.1) (Table 3).

Lung Cancer: Axelson-Adjusted US Rates Comparison

The cohort of non–cigarette-smoking miners used in this secondary comparison consisted of the 516 nonsmokers plus 77 cigar and pipe smokers for a total of 593 nonsmokers. Cigar and pipe smokers were included because the data regarding the smoking habits of the US population included cigar and pipe smokers among nonsmokers of cigarettes. When the numbers of expected lung cancer deaths in the United States among white men were estimated for non–cigarette smokers by the Axelson method, we estimated the SMR to be 9.3 (95% CL, 5.6 and 14.5), based on 19 observed and 2.04 expected deaths.

Using the Axelson method, we estimated the following lung cancer rates for non–cigarette smokers in the United States: (1) 12% of the known overall US lung cancer rate for white men, aged 45 through 64 years, during the period 1950 through 1974; (2) 25% of the overall rate for ages 65 years and older, 1950 through 1974; (3) 12% for ages 45 through 64 years, 1975 through 1984; and (4) 24% for ages 65 years and older, 1975 through 1984.

Table 2.—Characteristics of White, Nonsmoking, Uranium Miners Who Died of Lung Cancer

Case No.	Year of Death	Age at Death, y	Years Since First Exposure*	Year First Employed	Age First Employed, y	Duration Employed, y	Years Since Last Exposure†	Uranium Exposure, WLM‡	Other§ Exposure, WLM‡	Total Exposure, WLM‡	Months Under-ground	Rate of Exposure, WLM/mo‡
1	1965	57.1	15.3	1949	41.8	12.6	2.7	400	60	460	41	10
2	1972	73.1	21.6	1960	51.6	9.5	12.1	16 467	0	16 467	99	166
3	1972	42.1	17.5	1955	24.6	13.0	4.5	530	0	530	134	4
4	1973	67.9	13.9	1959	53.9	8.1	5.8	720	74	794	96	7
5	1975	53.0	20.5	1954	32.6	10.2	10.3	686	7	952	116	5
6	1975	62.3	16.5	1958	45.7	8.9	7.6	2934	54	2988	92	46
7	1976	54.6	36.2	1940	18.6	26.6	7.6	2989	0	2989	214	14
8	1980	48.7	27.2	1953	18.5	15.9	11.3	2229	0	2229	134	19
9	1980	67.4	29.4	1950	37.9	13.6	15.9	4799	0	4799	157	30
10	1981	90.3	43.3	1938	15.9	30.6	12.5	4480	0	4480	347	13
11	1982	69.4	27.3	1955	42.1	9.1	18.2	952	0	952	101	9
12	1984	48.1	26.8	1957	18.3	10.9	15.9	1200	0	1200	80	14
13	1984	56.2	34.1	1950	22.1	17.0	17.1	1046	0	1046	102	11
14	1984	63.7	34.3	1950	49.5	13.6	18.7	1810	0	1810	160	11
Mean	1977	59.8	26.0	1951	33.8	14.6	11.4	2992	14	2998	139	27

*Time from first uranium mining until death; does not include other hard rock–mining employment.
†Time from last known uranium mining until death.
‡WLM indicates working level months.
§Other exposure to radon daughters from hard rock mining before uranium mining.

Table 3.—Lung Cancer Mortality Among Uranium Miners Aged 40 Years and Older Who Never Smoked Compared With Nonsmoking US Veterans

Time Since First Exposure to Uranium Mining, y	Exposure to Radon Daughters From Uranium Mining		
	1-359 WLM*	≥ 360 WLM*	Total
< 10			
No. of observed/expected deaths	0/0.2	4/4.2	4/4.4
Standardized mortality ratio	0.0	95.0	10.0
95% CL†	0.0-19.8	10.6-43.9	4.1-22.1
Person-years at risk			3439
WLM (%)‡			400 (90)
≥ 10			
No. of observed/expected deaths	6/6.2	104/4	110/7
Standardized mortality ratio	0.0	25.0	14.3
95% CL†	0.0-11.9	17.3-41.7	8.9-24.3
Person-years at risk			4425
WLM (%)‡			992 (466)
Total			
No. of observed/expected deaths	6/6.5	108/8	114/1.1
Standardized mortality ratio	0.0	23.3	12.7
95% CL†	0.0-8.8	17.2-37.9	8.0-20.1
Person-years at risk	4088	3788	7881
WLM (%)‡	114 (280)	889 (220)	296 (518)

*WLM indicates working level months.
†95% CL indicates 95% confidence limits for the standardized mortality ratio.
‡WLM (%) indicates median exposure from uranium mining for miners who did not progress to a higher category of exposure at time since first exposure, and parentheses indicate the number who did not progress to a higher category.

Nonmalignant Respiratory Disease

Because a significant excess risk of mortality from nonmalignant respiratory diseases (NMRDs) had been previously reported in studies of the Colorado Plateau miners[3,4] and because mortality from NMRDs is associated with smoking, we felt it would be important to report the NMRD mortality among this subcohort of nonsmokers. We calculated an SMR of 11.7 (95% CL, 5.1 and 23.1) for NMRD (*International Classification of Diseases, Ninth Revision*, disease codes 460 to 466, 470 to 478, 492, and 494 to 519) based on 8 observed and 0.682 expected deaths. Of the 8 observed deaths, 3 were caused by silicosis, 3 were caused by chronic obstructive pulmonary disease, 1 was caused by pulmonary fibrosis, and 1 was caused by pulmonary emphysema. The expected number of NMRD deaths was calculated by multiplying the rate of NMRDs among nonsmoking US veterans[20] in age groups 45 through 64 years and 65 years and older by the appropriate number of person-years from the nonsmoking uranium miners and adding the results.

COMMENT

Although models have been previously used to estimate the lung cancer risk among members of the US uranium miners cohort who never smoked (nonsmokers),[1] this is the first analysis of nonsmokers in which lung cancer mortality has been directly compared with a large referent group of nonsmokers. In this analysis, we also extended follow-up through 1984, assessed risk by personal cumulative exposure, and reviewed smoking status and corrected miscoding in this cohort. We found an overall SMR for lung cancer of 12.7 (95% CL, 8.0 and 20.1) for nonsmoking miners compared with a referent group of nonsmoking US veterans. In a secondary analysis that used a different referent group of US, white men adjusted for non-cigarette smoking via the Axelson method, we found an overall SMR of 9.3 (95% CL, 5.6 and 14.5) for non-cigarette smokers (including some pipe and cigar smokers).

Our overall lung cancer SMR of 12.7 (95% CL, 8.0 and 20.1) for white, nonsmoking uranium miners was in close agreement with the lower 95% CL of 14.4 for the odds ratio calculated in the study by Samet et al[5] of lung cancer among predominantly nonsmoking Navahoe exposed to uranium mining. The relative risk of lung cancer of 10.0 reported for nonsmoking Swedish iron ore miners by Radford and Renard[6] and for nonsmoking Czech clay shale miners by Sevc et al[7] were also in close agreement with our estimate, although the mean exposure to radon daughters for nonsmokers in the Swedish study (84.3 WLM) and in the Czech study (31.7 WLM) were only 28% and 11%, respectively, of the median exposure of 296 WLM (mean, 720 WLM) in our analysis. However, a greater difference did exist between our relative risk estimate of 12.7 and the estimate of 4.2 (11.0/2.6) for predominantly nonsmoking Navahos calculated in a previous analysis of the USPHS uranium miners cohort by Archer et al.[1] This difference is probably caused by the substantial lung cancer mortality that occurred among nonsmokers after the 1974 follow-up date for Archer's analysis.

Besides relative risk, attributable risk is frequently used to compare the results of studies of the association between lung cancer and exposure to radon daughters. In previous reports,[1,2] attributable risk has been defined as follows: Attributable Risk = ([Observed − Expected] / [Person-Years × Mean Dose]) × 10^6. We estimated an attributable risk of 5.5 excess lung cancer deaths per WLM per 10^6 person-years in our analysis of nonsmoking uranium miners (Table 3). This result is in close agreement with the estimate of 5.56 excess lung cancer deaths per WLM per 10^6 person-years estimated for nonsmoking Newfoundland fluorspar miners by Morrison et al.[3] However, it is below estimates of 16.3 for nonsmoking Swedish iron ore miners[6] and 16.6 for nonsmoking Czech clay shale miners.[7] The difference in the number of excess deaths per WLM among the studies might be caused by differences in the levels of exposure analyzed. The mean exposure in our analysis was 720 WLM (median, 296 WLM). The mean was approximately 447 WLM for all miners, smokers and nonsmokers alike, in the Newfoundland study. The mean exposure to radon daughters for nonsmokers in the Swedish study was 84.3 WLM and 31.7 WLM for nonsmokers in the Czech study. Thus, the mean exposures analyzed in our study and the Newfoundland fluorspar study were more than three times greater than the mean exposures in the Swedish and Czech studies, also leading to higher rates of exposure. It has been reported that radon daughters above certain exposure rates might be redundant or superfluous in increasing the risk for lung cancer.[6]

Our examination of the USPHS questionnaire data regarding white nonsmokers from the Colorado Plateau study group revealed that 12% of the miners coded as nonsmokers should have been coded as smokers or ex-smokers of cigarettes. However, the miscoding appeared to be random with relation to lung cancer cases and noncases and, thus, did not have a significant effect on our overall risk estimate. In our analysis of the corrected nonsmokers group, the total number of lung cancer deaths declined from 20 to 14 (30%), the expected number of deaths declined from 1.7 to 1.1 (35%), and the overall SMR rose from 11.7 to 12.7. Although miscoding might also have occurred among

miners coded as smokers or ex-smokers, it seems more likely that smokers would have been incorrectly coded as nonsmokers than the other way around.

Errors in the classification of exposure to radon daughters might also have occurred. The coefficient of variation for the radiation exposure for the entire cohort of white, US, uranium miners was previously estimated to be 97%.[7] This implies that many miners might be classified in the wrong exposure categories. This misclassification, however, is independent of the exposure-disease relationship because the exposures were determined without knowledge of the disease outcome. Random misclassification has been shown to bias the mortality ratio toward 1.00, causing an underestimation of risk.[8]

Miners are exposed to radon daughters, not only from uranium mining, but from other underground, hard-rock mining as well. One hundred forty-two of the miners (28%) in our cohort had exposure to radon daughters from previous hard-rock mining. Their mean exposure from previous hard-rock mining was 46 WLM (median, 21 WLM). Although we did not consider these prior exposures in our analysis (Table 3), they were relatively small and would not have caused any of the deaths from lung cancer to enter different categories of exposure to radon daughters.

Besides radon daughters, the miners in our cohort might also have been exposed to diesel exhaust, silica, arsenic, nickel, cobalt, γ-radiation, and other substances associated with mining. Although these exposures were not considered in our analysis, they might have acted synergistically with radon daughters to potentiate the effects of exposure to radon daughters.

In our SMR analyses, we observed no deaths and thus estimated a relative risk of 0.0 for lung cancer among nonsmokers who fell in the exposure category of less than 360 WLM (Table 3). However, our power to detect any excess risk at lower exposure levels was low. For example, to have attained statistical power of 0.80 in the exposure category of less than 360 WLM and greater than 20 years since first exposure, an SMR of 10.37 would have had to exist with 0.3 expected deaths from lung cancer.[9] The power to detect a risk of 2.00 was 0.12.

An important consideration in using both the US veterans comparison population and the smoking-adjusted US comparison population, which we used for corroboration, was our selection of rates[10-12] and risk estimates[9] from the study of US veterans. The authors of that study noted that the veterans were mostly from World War I and were drawn mainly from the middle and upper socioeconomic classes and hence might not be very similar to Colorado Plateau uranium miners. However, our results would have been largely unchanged had we used the rates calculated by Hammond and Seidman[13] for American Cancer Society volunteers, the only other principal US cohort of smokers and nonsmokers studied prospectively (1960 to 1972). The veterans' rates seemed more appropriate because they covered the entire study period for the uranium miners—1950 through 1984.

In conclusion, we have demonstrated a 12-fold mortality risk for lung cancer for nonsmoking uranium miners exposed to radon daughters at a median level of 296 WLM (mean, 720 WLM) when compared with nonsmoking nonminers. No deaths from lung cancer were observed among nonsmoking miners who had accumulated less than 468 WLM of exposure to radon daughters; however, our statistical power to detect risks at lower exposures relevant to current occupational and most household exposures was not adequate in this analysis. These results confirm that exposure to radon daughters in the absence of cigarette smoking is a potent carcinogen that should be strictly controlled.

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Chapter 123

Mortality Follow-up Through 1977 of the White Underground Uranium Miners Cohort Examined by the United States Public Health Service

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Introduction

Since excess lung cancer mortality was first noted in the late 1800's among Joachimsthal-Schneeberg miners, there have been a number of studies of the long term health effects among various types of miners exposed to elevated levels of radon and its radioactive decay daughters. Substantial excesses of lung cancer have been noted among miners in the Joachimsthal mines (Sevc, 1976), lead-zinc miners in Sweden (Axelson, 1979), fluorsper miners in Canada (DeVilliers, 1971), iron miners in Sweden (Renard, 1976), uranium miners in Canada (Hewitt, 1976), and metal (Wagoner, 1963) and uranium miners in the United States (Lundin, 1971; Archer, 1976).

The latter prospective cohort has also been shown to be at an excess risk of death due to tuberculosis, nonmalignant respiratory disease, and accidents when followed through September 30, 1974 (Archer, 1976). This report extends the followup of this cohort of miners through December 31, 1977 and expands the mortality analysis to investigate more cause-specific categories.

Methods

During the decade beginning with July, 1950, medical teams from the United States Public Health Service (USPHS) examined 3342 white and approximately 780 nonwhite males who had worked underground in uranium mines in the Colorado Plateau at least one month by January 1, 1964. Occupational, medical, and smoking histories were obtained during the examinations and often updated/confirmed during subsequent annual censuses of the miners conducted by the USPHS.

The white miners now have been followed-up through December 31, 1977 using the Social Security Administration, Internal Revenue Service, direct telephoning and various other sources. Death certificates were obtained for the deceased and coded directly into the Seventh Revision of the International Classification of Diseases, Adapted, using the rules in effect at the time of death. Deceased miners for whom no certificate has yet been located were assumed dead on the date specified by the reporting agency, cause of death unknown.

The uranium miners cohort was analyzed using a modified life-table system developed by the National Institute for Occupational Safety and Health (NIOSH). Person-years at risk of dying (PYAR) were calculated for each miner from his first USPHS medical examination date or date upon completion of one month of underground uranium mining if that was later.

PYAR were calculated specific for five-year age groups, calendar periods, and periods after first underground uranium mining. The numbers of cause-specific observed deaths among the cohort occurring by December 31, 1977 were compared to the numbers of expected deaths. The expected deaths were calculated by multiplying the appropriate PYAR by the United States death rates for white males specific for five-year age groups, five-year calendar periods, and cause. The results were summed over the age and calendar period specific categories to obtain the total expected deaths for each cause.

Standardized Mortality Ratios (SMR's) were calculated for each cause by dividing the observed number of deaths by the expected number of deaths and multiplying by 100. In some tables, two-sided 95% confidence intervals for the SMR's were computed using either Fisher exact confidence limits, if the observed frequency was less than eight, or approximate confidence limits, if the observed frequency was eight or greater, to indicate statistical significance. Because a priori hypotheses had been well established, one-sided lower confidence limits were used for tuberculosis, lung cancer, other nonmalignant respiratory disease (ONMRD), accidents, and total mortality.

Results

The cohort included 589 miners first examined in either 1950, 1951 or 1953; 753 first examined in 1954; 1235 first examined in 1957; 5 first examined in 1958; and 782 first examined in 1960. In Figure 1 the distribution of the cohort by first year of underground uranium mining indicates that 13.7% started before 1947 and would have thus had an opportunity to be followed beyond 30 years

FIG. 1 DISTRIBUTION OF FIRST YEAR EMPLOYED AT URANIUM MINING FOR WHITE MALE MINERS

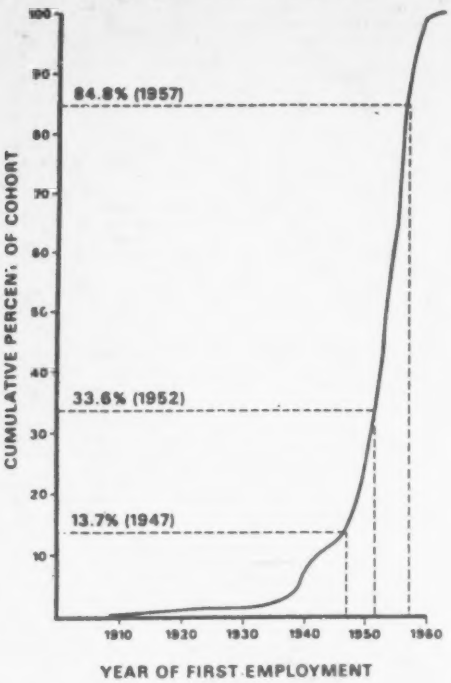
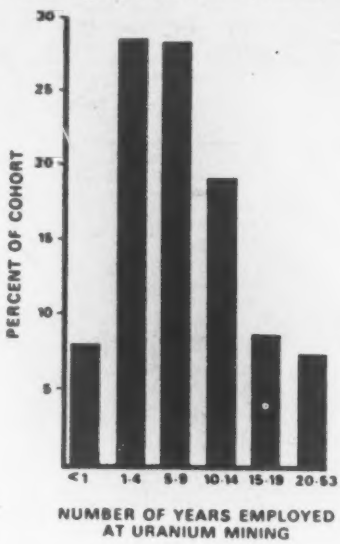


FIG. 2 DISTRIBUTION BY NUMBER OF YEARS EMPLOYED AT URANIUM MING FOR WHITE MALE MINERS



since first underground experience. Fifty-one percent of the cohort was hired between 1952 and 1957. By 1977 these men had reached a 20-25 year induction-latency period. Turnover was substantial (Figure 2); the majority of miners having worked less than 10 years in uranium mines. The median age at first uranium mining was 30.

[redacted] underground miners resulted in only three persons [redacted] (Table 1) and the [redacted]. Death certificates are still outstanding for 33 (3%) of the deceased, 5 of whom died before 1970, 13 between 1970-1974, and 15 after 1974. Only 4 of these 33 deaths occurred after 25 years since start of underground uranium mining. The cohort, whose average cumulative dose of radiation from radon daughters was [redacted] = 430 WLM), was followed up an average of 19 years, generating 62,556 person years at risk.

Observed and expected deaths for 87 causes of death were examined; some of those with small numbers are not reported, leaving the 51 causes in Table 2. Overall, 950 deaths were observed, producing an SMR of 158 among these miners. Among these 950 deaths were approximately 50 who died before September 30, 1974 yet presumably were lost-to-follow-up at the time of the previous report (Archer, 1976) and were thus reported as such, ie. included in the total of 60 then untraced.

The excess risk of tuberculosis (SMR=409) is based on 14 observed deaths. These are substantially more deaths due to this cause than the three reported by Archer and appear to be due to a nosology error in the 1976 report. [redacted] None of the 14 cases had prior surface mining experience, over 10 years for six of them. However, one case of silicotuberculosis had only prior coal mining experience while two others had no prior mining experience at all.

A two-fold risk of death due to all malignant neoplasms was noted. No deaths due to buccal cavity, pharyngeal, or nasal cancer were observed. [redacted] was noted for cancer of the trachea bronchus, and lung, subsequently referred to as lung cancer. Using the formula for attributable risk, it appears that 80% of the deaths due to lung cancer in this cohort were attributable to uranium mining. Elevated risks of

death due to stomach, pancreatic, prostate, and skin cancer were noted for the first time among this cohort, although none were statistically significant. Pathology reports have been requested on persons who died from these malignancies according to their death certificates. Some reports have been received. For three cases whose death certificates read pancreatic cancer and one whose certificate read stomach cancer, the pathology report indicated primary lung cancer. Another whose death certificate stated pancreatic cancer was actually a primary malignancy of the bile duct.

Although other studies of persons exposed to radiation have found associations with increased risks of leukemia, lymphoma, multiple myeloma, and cancer of the colon, liver, brain, and thyroid, no excesses due to these causes were evident. One case of breast cancer and one of bone cancer were observed.

In contrast to the deficit of deaths due to cirrhosis, a statistically significant twofold excess of death due to alcoholism was found. No excess of deaths due to circulatory system disease occurred; in fact, the SMR of 86 indicated the existence of a healthy worker selection for this occupational cohort. Despite this overall deficit, excess risks were evident for three subcategories of heart disease, namely, rheumatic fever, chronic rheumatic heart disease, and "other" heart disease.

The excess risk of nonmalignant respiratory disease, when examined in this update by cause, appeared to be limited to a [redacted] respiratory disease". The latter consisted mainly of silicosis, emphysema, and fibrosis. The nonsignificant excess of observed deaths due to diseases of the stomach and abdomen were all (six) due to ulcers. The excess mortality from accidents was not limited to any single type of accident but appeared to be greatest for "other" or miscellaneous accidents, many of which were work related. In fact, more excess deaths occurred among miners due to "other accidents" than due to "other nonmalignant respiratory disease".

Perhaps the most important new finding was the statistically significant excess of mortality due to chronic nephritis and renal sclerosis. Upon further investigation of these deaths due to kidney disease, (Table 3), one of the death certificates mentioned proximal renal tubular degeneration, an unusual kidney disease that has been induced experimentally in animals exposed to uranium. Two of the certificates mentioned glomerulonephritis (or Bright's disease). A third case died from Goodpasture's syndrome, an immunologically mediated glomerulonephritis. This case is included in the case listing but not in the computation of SMR's since its ICDA code falls into a non-renal category. For case number 9, systemic silicosis was mentioned on the death certificate. Two of the cases also had worked for three years each in uranium mills. All of these deaths occurred in the period 1962 - 1973 with a median of 17 years since first underground uranium employment. All but two cases first worked underground after 1950.

Indicated in Table 4 are the temporal changes in risk for selected causes of death. The excess of deaths due to lung cancer, in both the relative and absolute sense, appears to have peaked during 1965-1974. The excess mortality due to "other NMRD" exists in all time periods and a well defined unimodal curve is not evident. Excess deaths due to chronic nephritis and renal sclerosis have so far only been identified from 1960-1974. The excess risk of accidental deaths has declined since the late 1950's, but still remains elevated two-fold.

In an attempt to account for the strong healthy worker effect that often occurs in the first years after initial employment in an industry and in order to account for the induction-latency period of certain chronic diseases, mortality was examined by time after first uranium mining (Tables 5 & 6). No notable trends were seen for the majority of diseases. However, a greater relative excess after 10 years since first uranium mining did exist for nephritis. Further investigation of the relative risk of death due to chronic nephritis after 10 years induction-latency had elapsed revealed a sharp increase with duration of underground mining. There were 2 observed and 0.9 expected deaths below 5 years duration of underground uranium mining, 2 observed and 0.6 expected deaths from 5-9 years duration, and 3 observed versus 0.5 expected for 10 or more years duration.

The SMR's for deaths due to tuberculosis and accidents decreased from the shorter to the longer induction-latency periods. The SMR's for both lung cancer and ONMRD were strongly associated with the induction-latency periods beyond 4 years in Table 6. They peaked beyond 25 years since first uranium mining. Despite the increased observation period since the previous report, no lung cancer cases occurred among miners with less than 300 WLM..

Before age 50, these miners experienced a two-fold risk of total mortality (Table 7). The major components of this excess risk were lung cancer and accidental mortality. The SMR's for all-causes decreased with age. Most of the decline was due to decreasing risks of death from lung cancer, accidents and ONMRD.

Table 1

Vital Status of Cohort of White Uranium Miners

	Number	Percent
Alive	2409	72
Deceased	950	28
Certificate Obtained	917	97
Certificate Outstanding	33	3
Lost to Follow-up	3	0.1
Total	3362	100

Table 7

Cause-Specific Mortality Among a Cohort of White Male Uranium Miners
Followed Through December 31, 1977

CAUSE OF DEATH	ICDA* (7th Rev.)	OBSERVED	EXPECTED	SMR	95% Confidence Intervals**
Tuberculosis	(001-019)	14	3.4	409	267-
All Malignant Neoplasms	(140-299,	364	317.2	775	199-744
Buccal Cavity and Pharynx	(140-149)	0	4.0	0	
Esophagus	(150)	2	2.0	72	9-260
Stomach	(151)	9	6.0	150	68-284
Intestines including Colon	(152,153)	7	10.7	69	28-141
Rectum	(154)	1	3.7	22	1-150
Liver and Biliary Tract	(155,156a)	2	2.8	71	9-256
Pancreas	(157)	9	6.6	137	63-260
Larynx	(161)	0	1.9	0	
Lung	(162,163+	185	38.4	482	425
Breast	(170)	1	0.2	453	11-2041
Prostate	(177)	7	5.9	118	47-243
Kidney	(189)	1	3.0	33	1-184
Bladder	(181)	3	3.2	94	19-274
Skin	(190,191	5	2.3	216	70-504
Brain Tumors	(193,225,237)	4	5.3	75	21-193
Thyroid	(194)	0	0.3	0	
Bone	(196)	1	0.6	153	4-877
Lymphatic & Hematopoietic	(200-209)	9	12.0	75	34-142
Lymphosarcoma and Reticulosarcoma	(200)	2	3.1	55	7-198
Hodgkins Disease	(201)	1	1.8	55	1-309
Leukemia	(204)	5	4.8	104	34-243
Other Hematopoietic and Lymphatic Malignancies	(202,203, 205)	1	1.7	58	1-324
Diabetes Mellitus	(260)	4	8.5	47	13-121

CAUSE OF DEATH	ICDA* (7th Rev.)	OBSERVED	EXPECTED	SMR	95% Confidence Intervals**
Alcoholism	(1771)	7	2.6	271	110-561
Vascular Lesions Affecting Central Nervous System	(330-334)	29	34.6	84	56-101
Diseases of the Circulatory System	(400-448)	733	746.6	87	77-99
Rheumatic Fever	(400-402)	7	0.7	1093	132-3948
Chronic Rheumatic Heart Disease	(410-416)	11	6.1	181	90-324
Arteriosclerotic Heart Disease	(420)	467	470.9	99	90-108
Other Heart Disease	(421-434)	78	46.4	171	111-267
Nonmalignant Respiratory Disease	(470-527)	103	31.6	326	266-396
Acute Upper Respiratory Infection	(470-475)	0	0.1	0	
Influenza	(480-483)	0	0.0	0	
Pneumonia	(490-493)	68	12.1	564	69-204
Bronchitis	(500-502)		7.1	234	76-540
Other Respiratory Diseases	(510-527)		16.6	499	61-
Diseases of Stomach & Abdomen	(540,541,543)	6	4.6	130	48-284
Hernia & Intestinal Obstruction	(560,561,570)	4	7.1	102	57-401
Cirrhosis	(581)	14	10.1	77	42-130
Acute Nephritis	(590)	0	0.3	0	
Nephritis with Edema including Nephrosis	(591)	1	0.1	588	30-2161
Chronic & Unspecified Nephritis and Renal Sclerosis	(592-594)	8	3.1	257	111-506
Kidney Infection	(600)	0	1.4	0	

CAUSE OF DEATH	ICDA* (7th Rev.)	OBSERVED	EXPECTED	SMR	95% Confidence Intervals**
Accidents	(800-962)	155	46.8	331	299-
Transportation	(800-846)	67	26.4	178	131-237
Poisoning	(870-895)	5	1.9	259	84-604
Falls	(900-904)	10	4.7	211	101-387
Other Accidents	(910-936, 960-962)	91	12.9	707	569-868
Suicides	(963, 970-979)	29	16.0	150	96-223
Homicides	(964, 980-989)	6	4.9	87	32-211
Residual+		40	29.1	137	98-187
Unknown Cause		64++	7.1	670	450-832
TOTALS		950	648.3	150	150-

Note:
+Residual: calculated by subtraction of the major groupings from all causes.
*International Classification of Diseases, Adapted
**Includes 33 death certificates not yet processed
***Lower Limit for one-tailed test or lower and upper limits for two tailed test

Table 3

Deaths Due to Chronic Nephritis and Renal Sclerosis Among Uranium Miners

Case	7th Rev. ICDA	Death Certificate Diagnosis	FIM*	Dur‡	CMLR	Age	DOD	Latency	Significant Other Work
1	056	Uremia, Goodpasture syndrome (4 mos.)	7/52	11-11	1076	35	8/68	16	Copper smelter 1952
2	592	ALS for renal failure (1 yr)	7/51	1-4	700	55	10/69	18	Uranium mill, 1955-1958
3	582	Glomerular nephritis old progressive (25 yrs)	2/59	7-8	1370	61	6/70	11	
4	593	Bright's Disease (4 yr.)	5/51	11-11	1145	64	7-71	20	Gold, lead, zinc, 1963+
5	593	Acute reaction & removal of renal graft (7 days)	7/53	11-4	1486	64	6/73	20	
6	593	Chronic renal failure (1 yr)	11/59	0-9	119	51	5-63	4	Lead, zinc, copper, gold miner, 1946-9
7	591	Subacute glomerular nephritis (7 mos.)	3/57	4-3	579	55	P 63	6	Molybdenum miner 1949+, Blacksmith 1951+
8	594	Uremia, proximal renal tubular degeneration (mos.)	7/57	8-11	895	62	11-67	10	Tungsten & other MB mining, 1930+
9	583	Emphysema, pulmonary fibrosis, silicosis (10 yrs.) renal & cardiac failure (60 days) Uremia (30 days)	7/76	1-8	744	65	8/42	36	Uranium mill leacher, 1946-9
10	592	Acute renal failure DC Chronic renal disease congestive heart failure (cor pulmonale), 3rd stage silicosis	7/60	16-6	2411	77	1/69	29	

*(FIM)= first date underground uranium mining
‡(Dur)= Duration of underground uranium mining experience

Discussion

Despite the probable existence of an underlying selection of relatively healthy persons into uranium mining as indicated by the low SMR for cardiovascular disease, there is no overall deficit of mortality or "healthy worker effect" as seen in most working groups. In fact the overall risk of death is 1.58 times that of United States white males. This is one of the highest risks of mortality reported in a working population, ranking about even with asbestos workers. A number of causes of death contribute to this excess, the most overwhelming being lung cancer, accidents, and nonmalignant respiratory disease -- all three previously recognized (Archer, 1976; Lundin, 1971). If regional lung cancer rates had been used for comparison instead of U.S. rates, the excess risk of lung cancer would have been even higher.

While the nephrotoxicity of uranium has been documented repeatedly in animals (Voegtlin, 1949), excess mortality from renal disease has not been reported previously among occupationlly exposed workers. It is unclear whether the overall observed three-fold excess of deaths due to chronic nephritis and renal sclerosis in this cohort is due to exposures to the uranium ore, to other exposures associated with mining, or to non-occupational risk factors. Although one death certificate mentioned renal tubular degeneration, the characteristic kidney lesion induced by uranium, renal toxicity from uranium would not be expected to occur among miners. This is because much of the uranium dust in mines occurs as oxides which are relatively insoluble; such compounds are cleared only slowly through the kidneys. Two of the cases had worked in uranium mills where they could have been exposed to "yellowcake" (ammonium diuranate), a more soluble and thus more nephrotoxic form of uranium. Five of these cases had occupational histories involving mining or smelting other metals, potentially exposing them to other nephrotoxins such as lead, gold and cadmium. Chronic renal failure is also a reported but unusual complication of silicosis (Haughustaine, 1980). In fact, the association of nephrotoxicity with mining may extend well beyond uranium mines. Statistically significant excess risks of death due to kidney disease have recently been reported among miners in general both in Washington State (Milham, 1981) and in the United Kingdom (Registrar General, 1978).

Pancreatic and skin cancer have been previously associated with radiation exposure (Mancuso, 1977; Sevcova, 1978). Mortality rates for these malignancies as well as lung cancer among white males in the 4 state area of the Colorado Plateau are generally lower than for the U.S. (Mason, 1974). Thus, use of U.S. rates for comparison underestimates the risk. However, the excesses of pancreatic and skin cancer found in this study did not show any concentration after 10 years since first uranium mining. Furthermore, of the seven deaths due to pancreatic cancer (according to the death certificate) that occurred after 10 years latency, three were actually misdiagnosed primary lung cancers. This is a much more frequent misdiagnosis of lung cancers to this cause than the 1% reported elsewhere (Percy, 1981). Therefore, the apparent excess of pancreatic cancer may, in reality, be a manifestation of the excess risk of

Observed (OBS) and Expected (EXP) Deaths Due to Selected Causes Among White Underground Uranium Miners by Calendar Time — Table 4

Years		Tubercu-losis (01-19)+	Lung Cancer (162,163)	Other NMRD (510-527)	Chronic & Unspecified Nephritis (592-594)	Accidents (800-962)	All Causes
1950-4	OBS	1	0	1	0	5	11
	EXP	0.3	0.3	0.1	0.2	1.6	10.9
	SMR*	333	0	1000	0	313	101
	95% CI*	15	--	46	--	122	57
1955-9	OBS	2	6	5	0	36	94
	EXP	0.8	2.2	0.8	0.6	7.1	55.1
	SMR	250	273	625	0	507	171
	95% CI	46	116	259	--	375	143
1960-4	OBS	5	23	14	2	52	184
	EXP	0.9	5.4	2.1	0.8	11.2	108.1
	SMR	555	426	667	250	464	170
	95% CI	219	291	403	30-896	364	150
1965-9	OBS	5	51	17	3	25	214
	EXP	0.7	8.8	3.8	0.7	11.7	144.2
	SMR	714	580	447	429	214	148
	95% CI	276	453	282	85-1204	148	132
1970-4	OBS	1	70	34	3	26	294
	EXP	0.5	12.5	5.6	0.5	10.1	171.0
	SMR	200	560	607	600	257	172
	95% CI	11	455	447	121-1710	180	156
1975-7	OBS	0	35	12	0	11	153
	EXP	0.2	9.2	4.2	0.3	5.0	111.0
	SMR	0	380	286	0	220	138
	95% CI		283	164	--	123	120

+ Seventh Revision, International Classification of Diseases, Adapted Code
*Standardized Mortality Ratio and 95% Confidence Interval (Lower limit for one-tailed test or lower and upper limits for two-tailed test)

Observed (OBS) and Expected (EXP) Deaths Due to Selected Causes By Years After First Uranium Mining Among White Underground Miners — Table 5

Cause of Death	ICDA* (7th Rev.)	≤10 Years OBS	≤10 Years EXP	≤10 Years SMR	≥10 Years OBS	≥10 Years EXP	≥10 Years SMR
Tuberculosis	(1-19)	7	1.4	500	7	2.0	350
All Malignant Neoplasms	(140-205)	28	21.9	128	236	95.3	248
Stomach	(151)	2	1.4		7	4.6	152
Liver	(155,156A)	0	0.6		2	2.3	
Pancreas	(157)	2	1.2		7	5.4	130
Prostate	(177)	0	0.6		7	5.3	132
Skin	(190-191)	1	0.5		4	1.8	
Brain Tumors	(193,223,237)	0	1.4		4	3.9	
Alcoholism	(322)	1	0.6		6	2.0	300
Chronic & Unspecified Nephritis & Other Renal Sclerosis	(592-594)	1	1.1		7	1.9	362
Accidents	(800-962)	81	17.5	463	74	29.3	253
All Causes		194	128.6	151	756	471.7	160

*International Classification of Diseases, Adapted
+Standardized Mortality Ratio

Table 6

Observed and Expected Deaths Due to Respiratory Diseases
By Years After First Uranium Mining Among White Underground Miners

Cause of Death		Year After Start of Underground Uranium Mining 0-4	5-9	10-24	25-29	30-34	≥35	Total
Lung Cancer	OBS	2	12	129	20	12	10	185
(ICDA, 162-163)	EXP	1.8	4.3	25.3	2.8	1.8	2.5	38.4
	SMR	111	279	510	714	667	400	482
	95% CI	20	159	438	480	390	217	425
Other Non-malignant	OBS	0	5	55	9	9	5	83
Respiratory Diseases	EXP	0.6	1.6	10.9	1.3	0.8	1.4	16.6
(ICDA,510-527)	SMR	--	312	505	692	1125	357	500
	95% CI		122	398	368	591	136	413

*Standardized Mortality Ratio and 95% Confidence Interval (Lower Limit for one-tailed test or lower and upper limits for two-tailed test)

Table 7

Observed and Expected Deaths Due to Selected Causes Among
White Underground Uranium Miners by Age

Years		Tubercu-losis (01-19)	Lung Cancer (162,163)	Other NMRD (510-527)	Chronic & Unspecified Nephritis (592-594)	Accidents (800-962)	All Causes
<50	OBS	4	44	10	4	117	289
	EXP	1.2	5.9	1.6	1.3	29.4	144.9
	SMR*	344	751	645	315	397	199
	95% CI*	117	575	350	86-807	339	181
50-64	OBS	6	106	49	3	32	444
	EXP	1.6	21.7	7.8	1.2	13.2	275.6
	SMR	365	489	631	257	243	161
	95% CI	159	414	490	53-752	177	149
65+	OBS	4	35	24	1	6	217
	EXP	0.6	10.9	7.3	0.6	4.2	179.8
	SMR	649	321	328	161	144	121
	95% CI	222	237	226	4-895	63	108

* Seventh Revision, ICDA Code
* Standardized Mortality Ratio and 95% Confidence Interval (Lower Limit for one-tailed test or lower and upper limits for two-tailed test)

small cell undifferentiated lung cancer among uranium miners together with the relatively advanced stage of the disease at which the cases first seek medical care. The excess of skin cancer among Czechoslovakian uranium miners reported by Sevcova was predominantly basal cell carcinoma. However, four of the five deaths in this study due to skin cancer were melanomas according to the death certificates. Other known radiosensitive site specific malignancies were not in excess with the obvious exception of lung cancer. Radon daughters attached to nonrespirable dust particles would be expected to settle in the nose and nasal pharyngeal regions, yet no malignancies of these sites were found.

The SMR for lung cancer appears to be dropping over the last 3 years compared to earlier periods even after accounting for missing death certificates. However, it is not known if this trend would persist if the lower regional mortality rates were used for comparison instead of U.S. rates. Regardless, for purposes of standard setting and of understanding human carcinogenesis, it is imperative that these miners continue to be followed to determine if this decrease in risk is real.

The substantial excess risk previously noted for NMRD is now seen to exclude influenza, pneumonia, and acute upper respiratory infectious disease mortality. It appears to have peaked before 1975, even after accounting for unobtained death certificates. Mortality risk from accidents although still elevated, has continued its decline since the late 1950's. This latter phenomenon is probably due to the fact that the accidential deaths on the job are less common as the conort members become acclimated to the underground environment or as they gradually drop out of the underground mining workforce and work elsewhere or retire. In fact, as of 1968, only 116 of the cohort were known to still be mining uranium.

One methodologic issue noted from this update is the importance of determining the vital status of the last few members of a cohort. In this case, the previous report left only 60 members, or 3% of the cohort, lost to follow-up, yet approximately 50 of them eventually were discovered to have died before the end of the previous follow-up period. If these deaths had been included in the previous report the all-causes SMR would have been increased by approximately 7%. The distribution of these additional deaths by cause would have increased some cause-specific SMR's even more. Similarly, in this report, certain cause-specific SMR's would increase once the 33 missing death certificates are obtained.

Future analysis will include follow-up of the Indian miners, and incorporation of WLM dose data, smoking data, and regional mortality rates.

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URANIUM MINING AND LUNG CANCER IN NAVAJO MEN

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Abstract We performed a population-based case–control study to examine the association between uranium mining and lung cancer in Navajo men, a predominantly nonsmoking population. The 32 cases included all those occurring among Navajo men between 1969 and 1982, as ascertained by the New Mexico Tumor Registry. For each case in a Navajo man, two controls with nonrespiratory cancer were selected. Of the 32 Navajo patients, 72 per cent had been employed as uranium miners, whereas no controls had documented experience in this industry. The lower 95 per cent confidence limit for the relative risk of lung cancer associated with uranium mining was 14.4. Information on cigarette smoking was available for 21 of the 23 affected uranium miners; eight were nonsmokers and median consumption by the remainder was one to three cigarettes daily. These results demonstrate that in a rural nonsmoking population most of the lung cancer may be attributable to one hazardous occupation. (N Engl J Med 1984; 310:1481-4.)

URANIUM miners work in an atmosphere that is contaminated by radon daughters, the short-lived decay products of radon gas. Investigations of uranium miners and other underground miners have established a causal association between inhalation of radon daughters and the occurrence of lung cancer.[1-4] However, only limited data have been available from nonsmoking miners.

In the United States, the uranium industry developed during the late 1940s in the Colorado Plateau region of Colorado, Utah, Arizona, and New Mexico, including portions of the Navajo Indian Reservation near Shiprock, New Mexico (Fig. 1).[4,5] Uranium production from this portion of the Navajo reservation reached a peak during the 1950s and declined through the mid-1960s. Navajo men who were employed as uranium miners worked primarily in this area, but some mined off the reservation as well. Little information has been published concerning working conditions in the mines on the Navajo reservation. Limited surveys by the Public Health Service and other agencies have documented exposures to radon gas and silica dust.[1,6,7] Anecdotal accounts describe dusty mines with little effective ventilation.[8-10]

Excess mortality from lung cancer has been demonstrated in Navajo men who mined uranium in this region. A follow-up study of 780 American Indian miners, primarily Navajos, showed 11 deaths from respiratory cancer through 1974, with only 2.6 expected.[11] Among 17 Navajo men with lung cancer who were admitted to the Shiprock Hospital between 1963 and 1979, 16 had mined uranium.[12]

Since 1969, the New Mexico Tumor Registry, a member of the National Cancer Institute's Surveillance, Epidemiology, and End Results Program, has ascertained all incident cancer cases in the Navajo population of New Mexico, Arizona, and Utah.[13] We have used this resource to describe further the importance of uranium mining as a cause of lung cancer in Navajo men, a largely nonsmoking group. To accomplish this goal, we have performed a population-based case–control study of all 32 cases of lung cancer diagnosed among Navajo men between 1969 and 1981.

METHODS

For this investigation, all cases of primary lung cancer (n = 33) (*International Classification of Diseases for Oncology*, code 162) in Navajo males included in the New Mexico Tumor Registry file on August 31, 1982, were selected. One subject with a histologically confirmed carcinoid tumor was excluded. Of the 32 remaining cases, 28 were histologically confirmed, two were diagnosed by x-ray film, and two were identified by review of death certificates. Twelve of these cases were included in the series of Gottlieb and Husen,[12] six in a report by Archer et al.,[11] and six in both.

For each case, two deceased Navajo male controls with cancer other than lung cancer were selected from the Registry files. Deceased controls were used because only two of the Navajo subjects with lung cancer remained alive at the time of this investigation and death certificates were one source for occupational histories. The controls were matched to the cases for age (± five years) and diagnosis date (± five years). The primary tumor sites for the 64 controls were digestive (n = 35), male genital (n = 5), kidney (n = 4), brain

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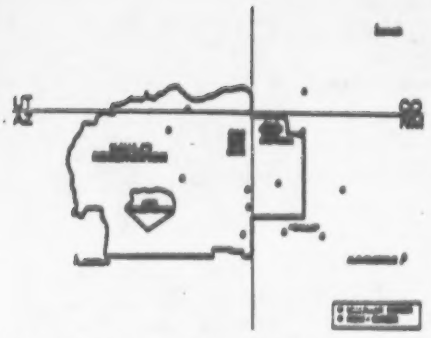

Figure 1. Residence at the Time of Diagnosis of Navajo Men with Lung Cancer.

(n = 2), lymphoma (n = 2), multiple myeloma (n = 1), leukemia (n = 4), and other, ill-defined and unknown sites (n = 8).

Sources of Data on Exposure

Multiple sources were used for all subjects to obtain information concerning occupation and smoking. For occupation, these included records maintained by the National Institute for Occupational Safety and Health (NIOSH), the Registry abstract of medical records, the occupation and industry stated on the death certificate, and listings of New Mexico uranium miners. Data from these sources were combined to determine whether each subject had ever been employed as a uranium miner. Each source is described separately below.

The major source of occupational data was the NIOSH rosters of uranium miners in the Colorado Plateau region, originally developed from annual censuses by the Public Health Service during the 1950s and 1960s and then maintained by NIOSH.[1,11] We were able to match 30 subjects, all cases, with this source on the basis of name and identical birth date or Social Security number (or both).

New Mexico Tumor Registry abstracts, completed for all cases and controls, sometimes mention occupation, although this item is not always available in charts and is not routinely collected. Relevant data from the abstracts were available for 21 cases and 25 controls. Death certificates could not be located for one case and five controls, and two cases remain alive. The 68 available death certificates provided information concerning occupation or industry for 21 cases and 32 controls.

Finally, we matched two cases with lists of New Mexico uranium miners that had been prepared for an ongoing mortality study.[14] The lists included most persons who had had a mining-related physical examination in the Grants, New Mexico, area between 1957 and 1976.

The cigarette-smoking history is not routinely collected by the New Mexico Tumor Registry, but was obtained repeatedly in the Public Health Service longitudinal study. Smoking histories were unavailable for controls and were available for only 21 cases — from the Public Health Service data for 19 and from the New Mexico Tumor Registry for 2. For seven subjects who reported inconsistently over time, we selected the maximum amount smoked. Five of the seven stated on at least one questionnaire that they had never smoked cigarettes, and none reported a maximum greater than a few cigarettes daily.

The dates of exposure and the cumulative doses of radon daughter exposure were available from NIOSH records.[1] Exposure to radon daughters is measured in working-level months (WLM). The working level is any combination of radon daughters in 1 liter of air that ultimately releases 1.3×10^5 MeV of alpha energy during decay. Working-level months of exposure are calculated as the product of duration of exposure (measured as 170-hour working months) and the working-level values in the mines.

Statistical Analysis

The data were analyzed with standard techniques for a matched case-control study.[12] The statistical significance of the association between lung cancer and uranium mining was tested with an exact test developed by Gart.[13] A lower 95 per cent one-sided confidence level for the relative risk (π) was calculated from the binomial distribution by setting $(r/\pi) \div 27^* = 0.05$, where r equals the number of exposure-discrepant triplets.[14]

For a further description of the effects of uranium mining in Navajo men, incidence rates were calculated with and without the cases in uranium miners. Mid-period (1975) denominators derived from Indian Health Service population estimates[15] were used. Rates were adjusted by the direct method to the age of the 1970 U.S. population for comparison.

Results

Of the 32 Navajo men with lung cancer in the period 1969–1981, 23 had been employed as uranium miners. This occupational history was documented for 20 by the NIOSH rosters and for the remaining 3 by New Mexico Tumor Registry abstracts. For 16 of the 20 included on the NIOSH lists, death certificates or New Mexico Tumor Registry abstracts were confirmatory.

A history of uranium mining could not be documented for any of the controls. One had worked in a lead, zinc, and silver mine. The association between uranium mining and lung cancer was statistically significant ($P = 1.1 \times 10^{-11}$). The estimate of relative risk was infinite because no controls were exposed. However, with use of the binominal distribution, the lower 95 per cent confidence limit for the relative risk was 14.4.

The age distribution of the affected Navajo uranium miners differed markedly from that of the affected Navajos who were not uranium miners and from that of men with lung cancer in the white U.S. population. The median age of the affected miners was 44 years, whereas that of the affected non-miners was 63 years — similar to that of affected men in the white U.S. population. The residences of the cases with a history of uranium mining were clustered in the northeast portion of the reservation around the Shiprock, New Mexico, and Cove, Arizona, areas where the mines had been located (Fig. 1). In 1975, the Indian Health Service unit that included these communities comprised 24 per cent of the total Navajo population. In contrast, the residences of the nine affected non-miners were scattered across Arizona and New Mexico, as were the residences of the controls. During the 12-year study period, the number of lung cancer cases among uranium miners did not decline; 11 were diagnosed during 1969–1972, and 9 during 1978–1981. The median age for the earlier group of cases was 42 years, as compared with 54 years for the more recent ones.

For the 23 cases with uranium-mining experience, the median duration of employment in underground mines was 12 years. Six were employed there for less than 10 years. The median duration from the start of employment in uranium mining until diagnosis (in-

[illegible] period was 23.5 years (range, 12 to 25), excluding one case for whom this period could not be determined.

Lifetime working-level months, calculated from job histories, were known for 14 cases and ranged from 30 to 2698, with a median of 1207. However, the two lowest values, 30 and 103 WLM, appear from our review of the records to be based on incomplete work histories. The third lowest value was 830.

Information concerning cigarette smoking was available for 21 of the 23 affected uranium miners (Table 1). Although the majority had smoked cigarettes, the amounts reported were low. Only five had smoked as much as four to eight cigarettes daily. No data on cigarette smoking were available for controls because the major source of these data was the Public Health Service records.

Table 1. Cigarette-Smoking Habits of 21 Male Navajo Uranium Miners with Lung Cancer.*

[illegible]	No. of Men
Nonsmoker	6
Smoker	
<1 cigarette/day	1
1–3 cigarettes/day	8
4–8 cigarettes/day	5

*Data were not available for 2 of the 23 cases of uranium miners.

Discussion

[illegible] American Indians have substantially lower rates of lung cancer than white and other nonwhite populations of the United States.[18-20] This pattern has been confirmed in the Navajo and other southwestern tribes by surveys, mortality, and incidence data.[21-24] A low prevalence of cigarette smoking by American Indians, as suggested by the limited available data,[22,25] is the most obvious explanation for these differences. Of the American Indian miners in the Colorado Plateau investigation, 62 per cent had never smoked, and the median consumption by smokers was only four cigarettes per day.[11] Of a sample of adult Navajos admitted to the Phoenix Public Health Service Indian Hospital from 1950 through 1965, only 4.3 per cent smoked more than one pack of cigarettes daily.[20] In a 1957 survey of Navajos, only 13 per cent smoked and only 6 per cent of the smokers consumed at least one pack daily.[25]

The present investigation thus offers an assessment of the role of a single occupational risk factor, uranium mining, in a population at low risk for lung cancer. Case ascertainment through a population-based tumor registry for the Navajo tribe facilitated examination of the effects of this exposure in the entire tribe in this study, unlike previous studies.[11,14]

The association between uranium mining and lung cancer among the Navajos was strong, with a lower 95 per cent confidence limit of 14.4 for the relative risk. In fact, 72 per cent of the cases (23 of 32) are attributable to this industry. For all male Navajos, the average annual age-adjusted incidence rate of lung cancer for the period 1969–1931 was 16.6 per 100,000. Exclusion of the affected uranium miners lowered the rate to 3.2 per 100,000. This finding demonstrates that in a population at low risk for a specific cancer, exposure to a single risk factor may have readily detectable consequences and cause the majority of cases.

Bias cannot satisfactorily explain the results, although selection and information bias are possible. With regard to selection bias, the diagnosis of lung cancer may be more vigorously pursued in younger men with a history of uranium mining. However, in the younger age groups in which the proportion of cases attributable to uranium mining is highest, contact with medical care and intensity of evaluation were probably comparable for miners and non-miners. With regard to information bias, death certificates and the New Mexico Tumor Registry abstracts provided more complete occupational information for the cases. The Public Health Service censuses, however, were the major source used for identifying uranium miners. These censuses were prospectively collected and uniformly applied to cases and controls. Because of the size of the Public Health Service study group (n = 7801), we expected to find that several controls had worked as uranium miners. The failure to identify any exposed controls may reflect better occupational information for cases or may have resulted from chance. Nevertheless, even if several controls had been uranium miners, the relative risk associated with this exposure would have remained high.

Differing smoking habits of cases and controls also cannot explain the effect of uranium mining. Because smoking histories were unavailable for controls, we could not directly assess the relative risk associated with cigarette smoking. In other populations, the relative risk for smokers of less than one pack per day ranges from approximately 2 to 10.[29] With a formula derived from a prospective study of British doctors,[29] we have calculated that the relative risk of lung cancer associated with smoking three cigarettes daily, the average consumption of affected Navajos who smoked, was only 2.3.

This investigation provides confirmation that uranium mining, without cigarette smoking, increases the risk of lung cancer in human beings. In animal models, inhalation of radon daughters alone causes respiratory neoplasms.[30,31] Supporting epidemiologic evidence has been available from few populations, including Colorado Plateau miners[1,11,14] and Swedish metal miners.[32,33] Smoking was probably not a prevalent risk factor among the early Schneeberg and Joachimsthal miners either, but documentation of their smoking habits is unavailable.[1,5]

Further follow-up will be needed for a complete characterization of the consequences of uranium mining in Navajos. The affected Navajos in this study were primarily younger men who began mining in the early 1950s. Exposure levels have declined since that

time,[10] and a federal standard of 4 WLM annually was implemented in 1971. More recent miners should have lower risks. However, the number of lung-cancer cases in Navajo uranium miners did not decline from 1969 through 1981, and more cases must be anticipated as these early miners age.

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RESPIRATORY DISEASE MORTALITY AMONG URANIUM MINERS

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Introduction

Uranium, as found in nature, is normally at or near equilibrium with its decay products, which include the inert gas radon. Because radon diffuses from the rock into open areas of mines, most underground miners are exposed to radon concentrations in excess of those found above ground. The range of atmospheric radon concentrations in mines varies widely from 1×10^2 picocuries per ml (pCi/ml) of air in potash mines to 30 pCi/ml in some poorly ventilated mines.

When pure radon is breathed, it diffuses throughout the body and gives what is essentially whole-body radiation. Its retention, however, is limited, since most inhaled radon is also exhaled within its half-life of 3.8 days. For the immediate daughters of radon, however, the story is different. These radionuclides (^{218}Po, ^{214}Bi, ^{214}Pb, ^{214}Po) collectively have an average half-life of about 30 minutes. When formed in the air of a mine, they quickly become attached to solid surfaces, most notably dust particles. When these dust particles with attached radionuclides are inhaled, the radiation from them (largely alpha particles) is delivered to those sites in the nose, pharynx, and tracheobronchial tree where the dust particles are deposited. The radiation dose delivered to the lungs of uranium miners by these elements is about 20 times greater than that from inhaled radon. Measurements of radiation exposure and of the biologic effects of this exposure on miners have been attempted repeatedly since about the year 1880.

Previous studies of United States uranium miners have shown that their risk of respiratory cancer is related to the magnitude of exposure to radon daughters.[1-3] A similar excess, however, was not clearly demonstrated among either non-cigaret-smoking white uranium miners or among non-white uranium miners (mostly American Indians).[4] Some publications reported a loss of pulmonary function among uranium miners,[5] but little attention was paid to their mortality from pulmonary insufficiency. An update of the earlier mortality studies now has been made that provides data for filling in these three deficiencies.

Materials and Methods

An intensive follow-up was done on the 3,366 white and 780 non-white workers who had been examined by our traveling medical teams between 1950 and 1960 and who had one or more months of underground uranium employment prior to January 1, 1964. Detailed occupational and smoking histories had been obtained by personal interview at the time of examination, in many cases

repeatedly. These data were supplemented by an annual census of uranium miners from 1954 through 1969 and by mail questionnaires.

The follow-up cut-off date was January 1, 1974, for Indians, and September 30, 1974, for whites. The followup was accomplished with the help of the Internal Revenue Service, credit agencies, state motor vehicle registrations, and telephone calls to relatives and trading posts (Indians), and by searching death certificate files in three states.

Death certificates were obtained for the known dead, and cause of death was interpreted according to the Revision of the International Lists of Diseases and Causes of Death in effect at the time of death by a qualified nosologist. Those individuals whose vital status was not ascertained were considered alive, thus making conservative any finding of increased cause-specific mortality among the study group. In addition, those individuals who had been reported dead but for whom no death certificates were obtained were considered as deceased on September 30, 1974, cause of death undetermined.

Cumulative radon-daughter exposure values were calculated for each miner from the date of his first mining to each sequential month of observation through September, 1969. These values were expressed as Working Level Months, that is, the cumulative product of length of underground exposure in working months (170 hours) and the concentration of radon daughters in "Working Levels" (WL) specific for mine and calendar year. One Working Level is equal to 1.3×10^5 MeV of potential alpha energy per liter of air. It was impractical to carry these calculations beyond 1969. Furthermore, little additional exposure was received by most of the workers after this date. Radiation levels in uranium mines dropped sharply after 1967, and relatively few of the study-group members continued mining uranium after 1967. With a dropout rate of 10–50%/year after 1960, it was determined in 1965 that only 12.1% of the study-group members were still mining uranium. The dropout has continued to date, but we have not determined the number still mining in 1974. It must be small.

A modified life-table technique was used to obtain person-months at risk of dying between August, 1960 and January 1, 1974 for Indians and between July, 1950 and September 30, 1974 for whites. The person-months were obtained for each calendar year for each five-year age group, for each time interval after the start of underground uranium mining, and by estimated cumulative radon-daughter exposure with estimated WLM from both uranium mines and other metal mines for whites, but just uranium mines for Indians, since few of them had ever worked in nonuranium mines.

Comparisons with the male non-white population of Arizona and New Mexico were made for Indians, and the male white population of the United States was used for white miners. Excesses and deficits were identified by noting the observed number of deaths among miners in relation to the expected number. This expected number was calculated by applying male rates specific for age, race, calendar year, and cause of death to the appropriate number of person-years at risk. No further analysis was done with the Indian mortality, since there were few respiratory cancers.

An exposure-response analysis by cigaret-smoking groups was done for both respiratory cancer and for all respiratory disease deaths other than tuberculosis and cancer among white miners. These diseases were largely pulmonary insufficiency and were recorded as pneumoconiosis, pulmonary fibrosis, emphysema, and others, but there were also a few pneumonias, asthmas, and so on.

The chest films made between 1950 and 1960 and the readings of them made by a panel of radiologists were available. The 98 persons found to have pneumoconiosis when examined were matched against the men who had died of respiratory cancer or "other respiratory disease," or who had some type of chronic obstructive pulmonary disease mentioned on their death certificates as "other significant condition," in an attempt to learn what contribution x-ray pneumoconiosis made to the later respiratory disease deaths.

Results

Follow-up was 100% among the Indians, with death certificates obtained on all deceased members. Only 60 white (1.8%) were lost to follow-up, and death certificates were obtained on all of the known dead. The seven unknown causes of death among Indians and the nine among whites had such notes as "natural causes" and "dead on arrival," with no further notations on the death certificates.

Table 1 shows that 107 deaths occurred among Indians during the follow-up periods. Among Indians, the overall expected and observed rates were about the same, but there were marked differences in distribution. Respiratory cancer was the only death cause which was significantly higher than expected. Three additional deaths were probably due to lung cancer, but were not studied sufficiently to establish the diagnosis. There was a trend toward excess deaths

Table 1

Observed and Expected Deaths by Cause among American Indian Underground Uranium Miners: January 1960–January 1, 1974

Cause of Death	List Number	Observed	Expected
Tuberculosis, all forms	001–019	8	3.7
All malignant neoplasms	140–205	17†	9.9
Digestive system *	150–159	4	3.8
Respiratory	160–164	11‡	2.6
All other malignant disease		2	3.5
Vascular disease of central nervous system	330–334	11	6.2
All heart diseases	401–443	21	19.2
All respiratory disease (nonmalignant)	470–527	7	5.4
Cirrhosis of liver	581	11	6.8
All accidental deaths	800–962	39	31.7
Motor vehicle	810–825, 830–835	21	16.2
All other accidental deaths		18	15.5
Suicide and homicide	963, 964, 970–979, 980–985	5	9.7
All other known causes		20†	31.3
Unknown causes		7	0.0
TOTAL		107	121.9

* Indented causes of death are not added into totals.
† Significant at < 5%.
‡ Significant at < 1%.

Table 2

Cigarette-Smoking Habits of the American Indian Miners

Packs per day	Smoking at Time of Examination	Amount Smoked by Former Smokers	Unknown	Never Smoked
0.0	—	—		487
0.1	117	18		
0.2	50	3		
0.3	23	2		
0.4	3	3		
0.5	37	5		
0.6	1			
0.7	2			
0.8	1			
0.9	1			
1.0	20			
1.5	1			
2.0		1		
Unknown			4	
TOTALS	256	32	4	487

for tuberculosis, other nonmalignant respiratory disease, and accidental deaths. There were significantly fewer deaths from heart diseases, from vascular disease of the central nervous system, and from liver cirrhosis than had been expected. Even if all the unknown causes of death were sudden death from heart attack or stroke, there would still be a deficit of these deaths.

The distribution of cigaret smoking among the Indians is given in Table 2 indicating that as a group they used little tobacco.

The 745 deaths among white miners (Table 3) are substantially greater than the expected number. Substantial excess deaths occur in three categories: respiratory cancer, nonmalignant respiratory disease, and accidents. Accidents while at work (most of the "other accidents") account for most of the excess deaths from this cause. There was a tendency toward elevated deaths from "all other malignant disease," and from motor vehicle accidents. The excess of both auto and other accidental deaths is greatest among inexperienced workers (less than 10 years on the job) and falls essentially to expected levels at 25 years after start of mining. Respiratory disease (both malignant and nonmalignant) is not elevated among workers with less than five years experience, begins to rise during the five- to ten-year period and rises rapidly with longer time intervals after the start of mining. There is a tendency to a deficit of deaths due to liver cirrhosis and to heart and other vascular diseases.

The exposure-response curves for both bronchogenic cancer and for pulmonary insufficiency show a clear relationship to cumulative exposure as expressed in Working Level Months (WLM) (Tables 4 and 5, Figures 1 & 2). The separation into cigaret-smoking groups clearly indicates that cigaret smoking has played a part in both cancer and pulmonary insufficiency deaths, but that both occur in the absence of cigaret smoke. The linearity of several of the curves, especially for nonsmokers, is remarkable.

TABLE 3

OBSERVED AND EXPECTED DEATHS BY CAUSE AND BY TIME AFTER START OF URANIUM MINING AMONG WHITE UNDERGROUND MINERS: JULY 1950–SEPTEMBER 1974

Cause of Death List	Years after Start of Underground Uranium Mining: 0–4.9 Obs.	0–4.9 Exp.	5–9.9 Obs.	5–9.9 Exp.	10–24.9 Obs.	10–24.9 Exp.	25 and over Obs.	25 and over Exp.	Totals * Obs.	Totals * Exp.
Tuberculosis 001–019	0	0.6	1	0.8	4	2.0	0	0.5	5	3.9
All malignant 140–205 neoplasms	6	6.9	22	15.1	142 †	56.2	36 †	15.8	206 †	93.9
Brain and nervous system 193 ‡	0	0.4	0	0.7	3	2.0	0	0.4	3	3.5
Digestive system 150–159	2	2.0	5	4.3	13	15.8	5	4.8	25	26.9
Respiratory system 160–164	2	1.9	12 †	4.6	103 †	18.3	27 †	4.9	144 †	29.8
Lymphatic & hematopoietic system 200–205	1	1.0	2	1.9	4	5.9	1	1.4	8	10.2
All other malignant diseases	1	1.6	3	3.6	19	14.1	3	4.2	26	23.5
Vascular disease of central nervous system 300–334	0	2.0	2	4.5	15	18.7	2	7.0	19 §	32.3
All heart disease 401–443	0 §	15.6	27	34.1	102	129.4	28	39.0	166 §	218.2
All respiratory disease (nonmalignant) 470–527	1	1.5	7	3.5	54 †	15.0	18 †	4.8	80 †	24.9
Cirrhosis of liver 581	0	1.2	0	2.6	7	8.7	0	1.8	7	14.2
All accidental deaths 800–962	42 †	7.2	41 †	10.1	51 †	22.5	6	3.6	140 †	43.3
Motor Veh. 810–825, 830–835	12	4.0	9	5.3	15	10.8	2	1.5	38 †	21.5
All other accidental deaths	30 †	3.2	32 †	4.8	36 †	11.7	4	2.1	102 †	21.8
Suicide and homicide 963, 964, 970, 979, 980–985	7 §	2.3	2	4.0	13	9.8	0	1.5	22	17.7
All other known causes	16 †	5.7	23 †	10.8	43	37.1	9	10.6	91	64.2
Unknown causes	1	0	0	0	7	0	1	0	9	0
Totals *	73	43.1	125	85.4	438 §	299.3	100	84.7	745 §	512.5

* Marginal totals may not check exactly because of rounding.
† Difference is significant at 1% level.
‡ Indented causes of death are not used in obtaining totals.
§ Difference is significant at 5% level.

TABLE 4

RESPIRATORY CANCER MORTALITY AMONG WHITE MINERS BY WLM AND BY CIGARET SMOKING, FIVE OR MORE YEARS AFTER START OF MINING: JULY 1950–SEPTEMBER 1974

Smoking Group	Working-Level Months: 1–359 Cancers	1–359 Person-Years	1–359 Cases per 1,000	360–1799 Cancers	360–1799 Person-Years	360–1799 Cases per 1,000	1800 and above Cancers	1800 and above Person-Years	1800 and above Cases per 1,000
Nonsmokers	1	4917.73	0.20	3	3487.94	0.86	2	1436.54	1.39
1–19 Cigarets/day	5	3169.42	1.58	3	2617.77	1.14	6	716.78	8.3
20 Cigarets/day	9	6907.38	1.30	29	8236.88	3.52	30	3175.38	9.4
Over 20 Cigarets/day	8	2944.12	2.72	17	3634.63	4.68	15	1126.53	13.3
Former Smokers	3	1009.6	2.97	6	1842.18	3.26	9	888.03	10.13

TABLE 5

MORTALITY FROM RESPIRATORY DISEASES OTHER THAN CANCER AND TUBERCULOSIS AMONG WHITE MINERS BY WLM AND BY CIGARET SMOKING FIVE OR MORE YEARS AFTER START OF MINING: JULY 1950–SEPTEMBER 1974

	Working-Level Months								
	1–359			360–1799			1800 and above		
Smoking Group	Resp. Deaths	Years Person	Cases per 1,000	Resp. Deaths	Person Years	Cases per 1,000	Deaths Resp.	Person Years	Cases per 1,000
Nonsmokers	3	4917.73	0.61	4	3487.54	1.15	2	1436.54	1.39
1–19 Cigarets/day	1	3169.42	0.315	8	2617.77	3.05	5	716.78	6.9
20 Cigarets/day	11	6907.38	1.59	14	8234.88	1.70	10	3175.58	3.1
Over 20 Cigarets/day	1	2944.12	0.34	6	3434.63	1.65	4	1126.53	3.54
Former Smokers	3	1009.63	2.97	6	1842.18	3.26	2	888.03	2.25

In the matching of these 98 individuals whose films had been interpreted as showing pneumoconiosis between 1950 and 1960 (TABLE 6), an apparent difference in frequency was found. However, since those men who had x-ray pneumoconiosis were generally older and had more mining experience than those without it, it is not appropriate to compare the two groups directly. The important parameter is the ratio of the three subsequent conditions. These ratios are nearly the same for both groups. In fact, the ratio of lung cancer to

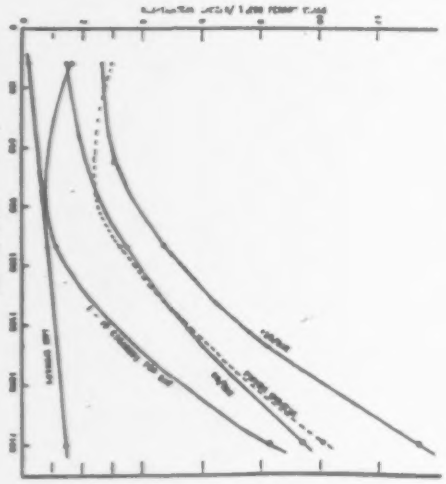

FIGURE 1. Respiratory cancer mortality as related to radon daughters, by cigaret smoking groups.

those who died of pulmonary insufficiency tends to be slightly higher among those who did not have x-ray pneumoconiosis.

"Other" accidental deaths among whites (mostly motor accidents, TABLE 6) show a drop from 0.4 times expected for the less than five-year group, with a steady drop to 2 × expected for the 25-year-and-over group.

Items of general interest on non-cigaret smokers are listed in TABLE 7. It should be noted that of the 17 men listed, only one ever smoked as much as 20 cigarets per day, and that of 15 whose histologic tumor type is known, all but three were small-cell undifferentiated.

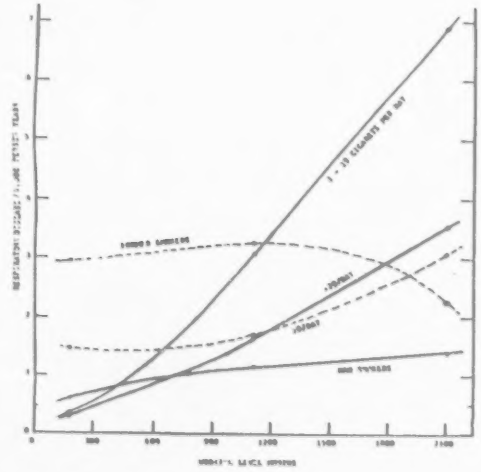

FIGURE 2. Respiratory disease mortality (other than cancer and TB) as related to radon daughters, by cigaret-smoking groups.

TABLE 6

OTHER ACCIDENTAL DEATHS AMONG WHITE UNDERGROUND URANIUM MINERS BY LENGTH OF MINING EXPERIENCE

Years After Start of Underground Mining	Observed	Expected	Ratio of Obs./Exp.
0-4.9	30	3.199	9.4
5-9.9	32	4.812	6.6
10-14.9	17	5.466	3.1
15-24.9	19	6.246	3.0
25 or more	4	2.078	1.9

DISCUSSION

The excess respiratory cancer among Indians not only shows that Indians are not immune to radiation-induced cancer, but also indicates that radio-induced bronchogenic cancer occurs when cigaret usage in the exposed group is minimal or absent (TABLES 7, 8). Of the 14 respiratory cancers among Indians (including three not definitely diagnosed), four stated, at time of examination, that they never smoked, two smoked two to three cigarets/week, six smoked two to six cigarets/day, one smoked one to ten/day, and one smoked ten to twenty/day. The time from start of mining to cancer (induction-latent period) for these fourteen men range from 11 to 24 years, with a mean of 17.1 years. The mean induction-latent period for the four nonsmokers was 20.5 years. These mean times may be contrasted with a mean of 13.7 years induction-latent period among 15 white uranium miners with lung cancer who smoked 20 cigarets or

TABLE 7

DATA ON INDIANS AND WHITE NON-CIGARET SMOKERS WHOSE DEATH WAS CERTIFIED AS DUE TO RESPIRATORY CANCER

Case No.	Age at Death	Usual Cigarette Usage	Years of Smoking	Induction-Latent Period	Histologic Type of Tumor WHO Classification *	WLM of Radon-Daughter Exposure	Race
7554	42	0	0	17	2B	867	Indian
3036	60	3-6/day	30?	24	1A	2760	Indian
0469	55	2-3/week	30?	14	2A	1325	Indian
7583	40	3-4/day	~3	20	2A	2039	Indian
3076	44	2-3/day	13	19	2A	702	Indian
7555	55	3-6/day	~15	17	2B	3234	Indian
3046	43	0	0	21	not available	3202	Indian
7551	39	0	0	21	not available	3052	Indian
10538	45	10-20/day	29	15	2B	2098	Indian
7577	56	2-3/week	20	15	2B	1413	Indian
3095	60	0	0	23	2B	1336	Indian
5806 †	73	0	0	23	3A	16467	white
0222	63	0	28 ‡	13	1A	2573	white
10360	56	0	0	13	2A	465	white
7607	67	0	0	14	2B	783	white
10777	42	0	0	18	2A	520	white
7050	62	0	0	17	2A	2900	white

* In the WHO Classification, 1A = well differentiated epidermoid; 2A = oat cell; 2B = small round or polygonal cell; and 3A = well-differentiated adenocarcinoma.
† Clinical data not clear as to origin; may have originated in colon.
‡ He smoked 6-10 cigars daily for 28 years.

more per day and died before 1961, when an excess was first clearly demonstrated among them. This shortened induction-latent period for heavy smokers has been previously demonstrated.[6]

The expected lung cancer rates calculated on the basis of non-white rates for Arizona and New Mexico is as close as we could get to appropriate rates, since there are substantial Indian populations in both states. There are, however, substantial numbers of blacks and orientals in both states who are included in the non-white mortality rates. The ratio of Indians to other non-whites is greater for these two states than for Utah or Colorado, where some of the Indian miners worked. Most of the Indian miners were Navajos from Arizona and New Mexico, although a few were born in Utah and Colorado. Male Indians (nonminers) have a total cancer and respiratory cancer rate that is

TABLE 8

RELATIONSHIP OF EARLY X-RAY PNEUMOCONIOSIS AMONG WHITE MINERS TO SUBSEQUENT BRONCHOGENIC CANCER AND CHRONIC OBSTRUCTIVE PULMONARY DISEASE

	No.	Men who Later Developed Bronchogenic Cancer	Men who Died of Pulmonary Insufficiency	Men who Had Chronic Obstructive Pulmonary Disease Noted on Death Certificate as "Other Significant Condition"	Ratio of Cancer:Insufficiency: D.C. Note
X-ray pneumoconiosis 1950–1960					
Number	98	17	15	10	1:0.88:0.59
Percentage	—	17.3	15.3	10.2	
No x-ray pneumoconiosis 1950–1960					
Number	3268	126	120	65	1:0.95:0.52
Percentage	—	3.8	3.7	2.0	

approximately half that of United States rates for white or non-white.[1,9] For this reason, the "expected" respiratory cancer rates in TABLE 1 are undoubtedly overestimated. It should also be noted that most Indian uranium mine respiratory cancers are of the small-cell undifferentiated variety (8 out of 9 with good histology were small-cell undifferentiated), similar to the predominant type among white uranium miners.[6] The radiation exposure among the 14 Indians ranged from 782 to 3234 WLM with a mean of 2004 WLM, which indicates that most of the cancers have come from the more heavily exposed groups, consistent with the findings among white miners.

The deficit of vascular diseases of the heart, kidneys, and central nervous system among Indians is thought to be due to a combination of medical selection of miners through preemployment examinations, to minimal tobacco use,

their diet, which is generally low in saturated fats, to a way of life involving considerable exercise, and possibly to a racial factor. Low death rates from cirrhosis of the liver among most employed groups probably reflects lower use of alcohol by working groups than by the general non-white population. Miners who abuse alcohol do not usually hold jobs very long.

The mortality pattern of white miners (TABLE 3, FIGURE 1) has changed somewhat from earlier reports. The excess of "other respiratory" and the deficit of cardiovascular disease deaths is a definite shift. The two may be related; i.e., men dying of pulmonary insufficiency might have died a few months or years later of heart disease. The death certificate coding appears to underestimate the magnitude of the shift, inasmuch as many of these heart disease deaths carry such notes as "right heart failure," "cardiorespiratory failure," emphysema, pulmonary fibrosis, and so on, often as an "other significant" entry.

The linear curves for nonsmokers in both FIGURES 1 and 2 argue for a direct dose-response in both respiratory cancer and "other respiratory disease" deaths. Some of the curves from cigaret groups are nearly linear also, but others are markedly curvilinear. The heaviest smokers have the highest incidence of respiratory cancer, as expected, but the differences between them and a pack-a-day or former smokers is not large.

The curves for light smokers are anomalous. At high radiation levels their cancer risk is nearly as great as among heavier smokers, but is much less at lower radiation levels. With respect to deaths from "other respiratory disease," the light smokers appear to have all the worst of it, and exhibit a more linear exposure-response curve than heavier smokers. This pattern suggests that heavy smoking may give protection against the development of parenchymal injury—possibly by the production of extra mucus, which shields cells from the minimally penetrating alpha radiation of radon daughters—but that light smoking does not give this protection. This apparent protection does not extend to cancer induction, however, which probably arises in the walls of larger bronchi.

No specific condition can be pinpointed as the cause of the excess "other respiratory disease" deaths. It appears to be pulmonary insufficiency resulting from diffuse radiation injury to lung parenchyma, leading to later fibrosis and emphysema. Cigaret smoke clearly contributes to it. Siliceous dust and diesel exhaust in mines would be expected to contribute an additional increment of damage.

The ratio of "other accidental deaths" (mostly due to mine accidents; TABLE 7) to expected, drops with time after start of mining. This undoubtedly represents a learning response, since beginners are at highest risk. This drop with time is in strong contrast to respiratory cancer and "other respiratory" deaths that rise with time. This latter pattern is typical of chronic occupational diseases: low initially, but constantly rising with increasing time after start of exposure.

The ratios of x-ray pneumoconiosis:lung cancer:pulmonary insufficiency deaths chronic obstructive lung disease noted as "other significant conditions" were surprising (TABLE 8). We had supposed that persons with x-ray pneumoconiosis would be much more likely to die of pulmonary insufficiency than other men. However, the ratios suggest that the earlier x-ray pneumoconiosis had little or no relevance to subsequent respiratory disease deaths, and that both types of disease (cancer and insufficiency) were primarily related to radiation exposure or cigaret smoking rather than to siliceous dust. This is consistent

with the data in TABLE 4 and FIGURE 2. An alternative hypothesis, not ruled out by present data, is that early x-ray pneumoconiosis increases lung susceptibility to both cancer and pulmonary insufficiency equally.

Data in FIGURE 1 and TABLE 7 clearly indicate that underground uranium miners who do not smoke cigarets or who smoke just a little, suffer an increased risk of lung cancer (most bronchogenic cancers among nonsmoking, nonminers are adenocarcinomas), although their risk is substantially less than that of heavy smokers.

In an earlier report,[9] with use of a computer model, it was calculated that for 30 years' exposure at 4 WLM/year, a group of 20-year-olds, by age 80 would have about a 45% increase of respiratory cancer over expected numbers. Since the bulk of expected cancers is due to cigaret smoking, this means that the respiratory cancer risk from 30 years' exposure at 4 WLM/year is about half that of smoking cigarets at the rate our miners have used them in the past. However, because there was some overestimation of exposures in that analysis, and because the median ten-year latent period now appears to be a little short, that earlier estimate of risk from 4 WLM/year is probably a little low.

SUMMARY

A mortality analysis of a group of white and Indian uranium miners was done by a life-table method. A significant excess of respiratory cancer among both whites and Indians was found. Nonmalignant respiratory disease deaths among the whites are approaching cancer in importance as a cause of death, probably as a result of diffuse parenchymal radiation damage. Exposure-response curves for nonsmokers are linear for both respiratory cancer and "other respiratory disease." Cigaret smoking elevates and distorts that curve. Light cigaret smokers appear to be most vulnerable to lung parenchymal damage. The predominant histologic cancer among nonsmokers is small-cell undifferentiated, just as it is among cigaret smokers.

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Lung Cancer Risks of Underground Miners: Cohort and Case-Control Studies

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All underground mines have higher radon levels than are found in surface air. Ventilation is the primary method of controlling radon levels. Fourteen cohort and seven case-control studies done on underground miners are reviewed; they include many types of ore. Only five of the studies deal with more than 100 lung cancer deaths. Variations in the attributable risk are given. Some generalizations can be drawn from these studies: the longer the follow-up, the greater is the attributable risk, even though the relative risk is reasonably constant. The induction-latent period is quite variable but is shortened by high exposure rates, by cigarette smoking, and by increasing age at start of mining. The predominant histological type of lung cancer among miners changed from small-cell undifferentiated for short follow-up time to epidermoid after long follow-up times. With short follow-up time, a multiplicative interaction between smoking and radiation was indicated, but, with long follow-up time, the two factors appear to be simply additive. The difference is probably due to the shortened latent period among cigarette smokers, not to synergism.

Any hole in the ground has higher radon levels than are found in the atmosphere. This classification includes caves and all types of mines. Coal mines are subject to a high risk from explosive mixtures; therefore, their ventilation has usually been adequate to keep radon levels low. Other mines have had much less ventilation; therefore, many of these have radon problems. Radon decays into radioactive isotopes of lead, bismuth, and polonium, which are inhaled as free ions or as attachments to dust particles; it is this radon progeny which delivers most of the radiation dose to lungs. The unit of measurement is the working level (WL): any combination of radon progeny in one liter of air which results in the ultimate release of 1.3×10^5 MeV of potential alpha energy. The unit may be converted to a cumulative term (working level months, or WLM) by multiplying the WL by the number of months exposed at that WL. One WLM is equivalent to a radiation dose somewhere between 0.5 and 2 rad (cGy). "Miner" in this paper refers to all underground workers.

Excess lung cancer (LC) has been noted among the Schneeburg and Jachymov miners of central Europe for hundred of years [1]. Selected information on recent studies of mining groups is given in Tables 1 and 2. The first cohort study was of U.S. underground uranium miners [1,2]; it was formed from all uranium miners examined periodically between 1950 and 1960. This group included 3,362 white miners; they had worked in many small, short-lived mines—about 2,500. About 43,000 measurements

Abbreviations: I-L: induction-latent LC: lung cancer WL: working level WLM: working level months

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TABLE I
Cohort Radon-Mining Studies and Lung Cancer

Senior Author	Year	Nation	Ore Type	Mean Follow-up Time (years)	Lung Cancer Deaths	Attributable L.C/WLM/10^6 Person-Years	Lowest Group Mean with Significant Excess (WLM)
Lundin [1]	1971	U.S.A.	Uranium	19	185	3 8	180
Archer [2]	1976						
Ševc [3]	1976	Czechoslovakia	Uranium	26	212	10-20	72
Ševc [4]	1987	Czechoslovakia	Uranium	30	484	16-42	63
	1987	Czechoslovakia	Iron	25	9	12	40
	1987	Czechoslovakia	Shale-clay	25	22	38	25
Muller [5]	1985	Canada	Uranium	18	119	2-12	65
Morrison [6]	1985	Canada	Fluorspar	30	89	6	700
Howe [7]	1986	Canada	Uranium	14	54	21	120
Radford [8]	1984	Sweden	Iron	44	50	19	81
Jungeneca [9]	1984	Sweden	Iron	31	28	13	96
Saih [10]	1985	Norway	Niobium	24	12	50	69
Wang [11]	1984	China	Tin	24+	499	7	140

TABLE 2
Radon-Mining Studies and Lung Cancer

Senior Author	Year	Nation	Ore Type	Mean Follow-up Time (years)	Lung Cancer Deaths	Attributable LC/WLM/10^6 Person-Years	Lowest Group Mean with Significant Excess (WLM)
Wagoner [12]	1963	U.S.A.	Copper	30+	47		<600
Boyd [13]	1970	U.K.	Iron		36		<200
Tirmarche [14]	1985	France	Uranium		36		<100
Pham [15]	1983	France	Iron	25	13		<150
Fox [16]	1981	U.K.	Tin		28		<400
Leino [17]	1986	Norway	Iron	33+	3	0	N.A.
			Case-Control Studies				
Damber [18]	1982	Sweden	Iron		20		<100
Edling [19]	1983	Sweden	Iron	40+	33	20-40	<140
Howin [20]	1976	Canada	Uranium	15	81	31	75
Axelson [21]	1978	Sweden	Lead-zinc	35+	21	20-35	240
Samet [22]	1984	U.S.A. Navajo	Uranium	25+	23		
Archer [23]	1985	U.S.A.	Uranium	30+	185		
Saccomanno [24]	1986	U.S.A.	Uranium	10+	489*		

*These were not deaths, but cases with sputum classification of moderate atypia or greater.

of radon progeny were made in the mines before 1970. Not all mines or all years were included in the measurements; therefore, many estimates were necessary in order to calculate cumulative WLM exposure for each miner.

Mortality follow-up of U.S. miners has been intermittent and is continuing every few years. An innovative life-table analysis demonstrated that the LC risk rose with increasing exposure, giving an exposure-response curve that extended from about 120 WLM to over 4,000 WLM. An attributable risk of 3 to 8 LC per million person-years was found. Analysis of smoking data demonstrated an interaction of radiation and smoking which was multiplicative in nature up to 1977 [25], but which was less than multiplicative (but more than additive) when data through 1982 were used [26]. The latest report on this cohort indicates that the LC risk per WLM is now greater than in earlier reports [26].

Of all the studies reported, this study is the only one done in a prospective manner. All others were retrospective, with cohorts being obtained from old employment or other records. Application of models to these data is discussed by Dr. Lubin in an accompanying article.

Another important study is from Czechoslovakia [3,4], which supplied much of the uranium for the Russian nuclear arsenal. The Czech exposure data all came from measurement of radon rather than radon progeny and had to be converted to a WLM equivalent. It is, however, probably better than the U.S. exposure data, since it came from a small number of mines that had undergone frequent radon measurements. This study has yielded a higher risk per WLM than did the U.S study and shows excess lung cancers at levels as low as 65 WLM. In the latest report [4], the risk per WLM is higher than it was in an earlier report that included less follow-up time [3].

There have been a series of reports from Canada [5–7], the most important one being that of Muller et al. [5], which included about 16,000 Ontario miners. This large study uses better exposure estimates and has longer follow-up than earlier studies; the follow-up time is still relatively short, however. The risk value is similar to the risk found in U.S. uranium miners. The exposure data is better than that for the U.S. study and is perhaps comparable to the Czech data.

The report by Morrison et al. on fluorspar miners from Newfoundland emphasized that uranium mines are not the only type of mines with a radon problem [6]. Its exposure estimates are more tentative than for most of the others in Table 1 because some of the mines had been closed before measurements were made. The results, however, are quite similar to those from other studies.

There are two cohort and several case-control studies from Sweden [8,9,18,19,21]. Sweden has no uranium mines, but they had a peculiar situation. When silicosis was recognized as a major problem in the 1920–30 period, most mining areas solved the problem by increasing ventilation. In Sweden, the extra ventilation caused severe problems from freezing, so they developed a method for warming the air: they circulated it through broken rock and old underground workings. This practice heated the air and solved the silicosis problem, but it gave them a radon and lung cancer problem which was not recognized for many years. The best of the Swedish studies is the one by Radford and Renard [8], which is notable for its long follow-up, the low average exposure, and the high LC risk per WLM. Extensive radon progeny measurements were first made in these mines in the 1968–72 period. Earlier exposures were estimated by considering changes in ventilation over time. They estimated the error in WLM estimates as ±30 percent. This precision, however, has been challenged

by others. Their analysis by smoking indicated that the attributable LC risks for smokers and nonsmokers were very similar—suggesting a simple additive effect between the two cancer-inducing agents.

Jorgensen's report from a different Swedish iron-mining area supports the results of Radford and Renard, with the exception that most of their LC occurred among cigarette smokers [9].

The largest study of all is the one from China, where boys were sold into bondage for work in the tin mines [11]. Their exposure data were scanty and recent, but their results tend to agree with other data. This study confirms other analyses, which have found that the younger a person is when he starts mining, the longer will be the induction-latent (I-L) period; that is, the time from start of mining to LC diagnosis will be lengthened when exposure occurs early in life. This lengthened I-L period, however, does not seem to diminish the lifetime risk.

The six cohort studies in Table 2 add little to our understanding of the radon problem, except to emphasize that the problem is found in many types of mines around the world, and that the risk appears at exposure levels of 100 WLM or less.

The case-control studies of Table 2 give about the same range of lung cancer risk as the cohort studies, but the populations of most were quite small. The Swedish studies listed here used general population controls matched on age and residence. The cigarette-radon interaction was considered by Damber and Larsson to be muluplicative [18], by Edling to be additive [19], and less than additive (smoking gave protection) by Axelson and Sundell [21]. The Axelson and Sundell study used miners who started mining at the turn of the century, but LC were collected only during a recent 20-year period. This delay gave them a very long follow-up period after start of mining, and most of the LC cases were old. Their analysis not only indicated a protective effect of smoking but yielded a high LC risk per WLM. The first Canadian study by Hewitt used a National Register to locate lung cancers [20]. A random 1 percent selection from this register was used for controls and was matched on age at start of mining. This study was heavily criticized when first published, but later cohort studies have given remarkably similar results, except that exposure estimates have been revised upward somewhat.

The study of Samet et al. was limited to Navajo Indians, who smoke very little [22]. This study was important because it demonstrated a high lung cancer rate among a group of miners who smoked very little, which showed that cigarette smoking is not essential for the high LC rates found among uranium miners. This feature was first exhibited by central European miners before cigarettes were invented [1].

The case-control study by Archer [23] was designed to answer criticism of earlier analyses, which had reported a shortened I-L period among cigarette-smoking miners. It controlled for date of birth, start of mining, follow-up period, WLM, and exposure rate; it again demonstrated that the I-L period is significantly shorter among smokers than among nonsmokers [23]. In all of the studies in Tables 1 and 2 which compared smokers and nonsmokers, the smokers had shorter I-L periods.

The study of Saccomanno et al. [24] was unique in that it used changes in exfoliated bronchial cells as the end-point, rather than cancer. The end-point was moderate atypia or more severe changes. Controls were miners who never had sputum with such severe changes. The analysis indicated that both smoking and radiation exposure contributed to the sputum changes and that the combined effect of the two agents was probably additive.

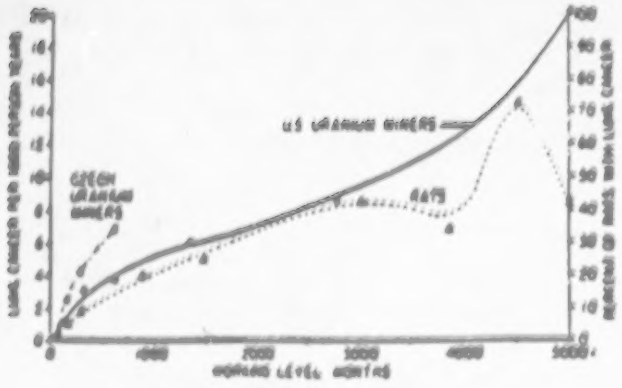

FIG. 1. Exposure-response curves for two cohort studies and for one animal study: exposures to radon daughters.

Statistically significant excesses of attributable LC were found by some of the studies in the 25–100 WLM range. Some of the studies found elevated LC rates below levels indicated in Tables 1 and 2, but numbers were too small for statistical significance. Some instances were reported of LC rates lower than expected at the lowest exposure level. This finding was attributed to the healthy worker effect, to short follow-up, or to small populations. The lifetime mean radon progeny exposure in residential houses is in the range of 10 to 20 WLM, with some homes giving exposures above 100 WLM. Extrapolation of LC data from miners to home situations is therefore reasonable, if allowance is made for differences in age and temporal factors.

The differences in LC risk per WLM indicated in Tables 1 and 2 are probably due to several factors: *(1)* errors in estimation of average worker exposures: none of the studies measured individual exposures, some had better and earlier measurements than others, and all had to estimate average mine WL levels over the years; *(2)* time of follow-up: in both the U.S. and Czech studies, risk per WLM has risen with longer follow-up, and those studies with the longest follow-up time in Tables 1 and 2 usually have yielded the highest risk per WLM; *(3)* variations in cigarette smoking among the different cohorts: in most of the studies the amount of smoking was unknown, but it is clear that smoking was much less prevalent among Swedish miners than among U.S. miners—yet the lung cancer risk per WLM found among Swedish miners has been consistently higher than among U.S. miners; *(4)* ethnic differences: there are some ethnic differences, but with the exception of the Chinese and Navajo reports, all the miners were of white European ancestry. Ethnic differences are probably not important in these comparisons.

These reports in Tables 1 and 2 which yield the lowest LC risk per WLM tend to have the shortest follow-up time and/or tend to have overestimated exposures. Those which have the highest LC risk per WLM tend to have the longest follow-up time and/or tend to have underestimated exposures.

One animal study [31] and two cohort studies [2,3] suggest that the exposure-response curve has a supralinear component at its lower end (Fig. 1). Analysis using a Cox proportional hazards model supports supralinearity [26]. This supralinearity might be an artifact resulting from misclassification of the exposure of some miners, but this explanation cannot apply to the rat study. It may simply be an artifact of small number of tumors at the lower end of the curve; it may also be an expression of the lower dose-rate received by the men with low WLM. In these studies, exposure rate

and cumulative exposure are generally proportional to each other. We are not at all sure of the existence of supralinearity, but it could have considerable significance for the problem of radon exposure in homes.

A number of the mines used in these studies contained small amounts of fibrous minerals, arsenic, or chromium in their ores, so etiology is not entirely clear. Only the Chinese tin mines had enough arsenic to be considered a problem in itself, yet their risk per WLM was similar to that found in other studies. Some of the mines, however, contained negligible amounts of these elements. The only known environmental exposures of a toxic nature that all of these mines had in common were silica and radon. There is little evidence that silica is carcinogenic in man.

Data collected early in the epidemic of lung cancer among uranium miners has been misleading in at least two ways. For example, when enough lung cancers among uranium miners had been collected to examine, a predominance of small-cell undifferentiated, mostly oat cell cancers were found [27]. It was announced that small-cell cancer was characteristic of radiation-induced LC. For several years, uranium miners with LC did not receive workers' compensation benefits unless they had a small-cell type.

Histologic data on LC continued to be collected. The frequency of small-cell LC among uranium miners declined sharply from about 60 percent in 1960 to 20 percent in 1980. Epidermoid types had shown a corresponding increase from about 20 percent in 1960 to 70 percent in 1980. This shift was readily apparent when the data were analyzed by age or by time after start of mining [28]. Apparently radiation induced several types of cancer, and the small-cell type was simply the one that appeared first.

Another example of misleading early data has occurred with the interaction of smoking and radiation. Nearly 80 LC had been collected from U.S. miners before the first one among a nonsmoker was found. This fact was interpreted by some to mean that smoking was much more important than radiation in causing LC among miners. One scientist even declared that if uranium miners would not smoke, they would not get lung cancer. In reviewing the studies listed in Tables 1 and 2, we noted that some found a multiplicative effect (interpreted as synergism), some found a simple additive effect, and one even found a protective effect from smoking. Each investigator felt that his results were right, and the others were wrong. The problem has recently been approached from another viewpoint [29]. This approach assumes that all the findings are correct but differ because each applies to different stages in the epidemiologic development of LC among miners.

In order for all the findings to be correct, we would need to have time-response curves for radiation-induced LC something like the ones in Fig. 2 [29]. These are hypothetical curves, which assume that both smokers and nonsmokers received the same radon exposure during the early period. It then projects their resultant lung cancer distribution by increasing age. Since tobacco smoke contains powerful cancer-promoting agents [30], we can hypothesize that radiation-induced LC among smokers appears fairly early, in short latent periods, and then drops off at advanced ages as the induced cancers are exhausted. The LC among nonsmokers would continue appearing to near the end of their life spans in proportion to LC rates expected from their ages.

If an epidemiologist collects his data while the men are mostly 35–65 years of age (as was the case with the early reports on U.S. miners), then a high proportion of the LC will be among smokers, and the radon-smoking relationship will appear to be multiplicative. Data collected while the miners are from 60–70 years of age will find

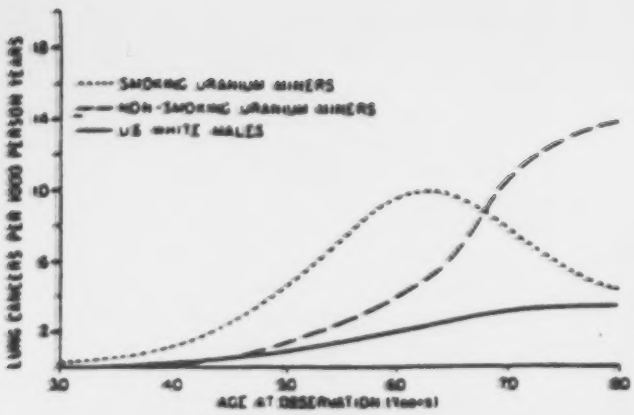

FIG. 2. Hypothetical curves for time distribution of lung cancers induced in smokers and nonsmokers by an equal radon daughter exposure between 30 and 40 years of age.

roughly equal LC rates among smokers and nonsmokers, whereas if LC are collected mainly from men 65–85 years of age, LC will appear predominantly among the nonsmokers, and one might conclude that smoking is protective. This method of data collection is essentially what Aaelson did—most of his LC were among retirees [21]. If one collects data over the whole life span, then the smoking and radiation effects would appear to be little more than additive. This result is approximately what happened in several of the studies [4,8,19].

To see if the types of age-related curves hypothesized in Fig. 2 might be appearing among the U.S. cohort, a recent analysis produced the curves given in Fig. 3 [29]. These data indicate that the lung cancer rate is still rising among nonsmokers of all ages, and among the younger smoking miners, but is falling rather sharply among the oldest group of retired smoking miners. Although the data are still not firm enough to be sure, they are consistent with the types of curves postulated in Fig. 2. A similar decreasing lung cancer rate at older ages is suggested among Czech miners, but that data does not separate smokers from nonsmokers [4]. The curves in Fig. 3 suggest that the attributable LC rates among persons over 65 years of age are similar for smokers and nonsmokers, even though the rates among younger smokers are much higher than those among corresponding nonsmokers.

Earlier LC data from U.S. uranium miners support the argument for a multiplicative (synergistic) interaction between cigarettes and radiation [25]. Figure 3 and the temporal change noted by Hoenung and Meinhardt [26], however, suggest that with the passage of additional time, the U.S. data may agree with the European data, which indicates an additive effect for the two agents [4,8,19].

The hypothetical curves in Fig. 2 require that the mean I-L period be shorter among smokers than among nonsmokers, and that the difference become larger as miners are followed longer. The mean of this difference was 5.3 years for U.S. uranium miners [23] and was nine years in the study with the longest follow-up after start of mining [21].

Animal studies have repeatedly demonstrated an interaction between cigarette smoke (or its components) and ionizing radiation [29]. With one exception, these studies have been interpreted as demonstrating a tumor-promoting effect by the cigarette smoke or components. Tumors in animals exposed to both agents have generally appeared earlier in time than in groups exposed to only one of the agents and

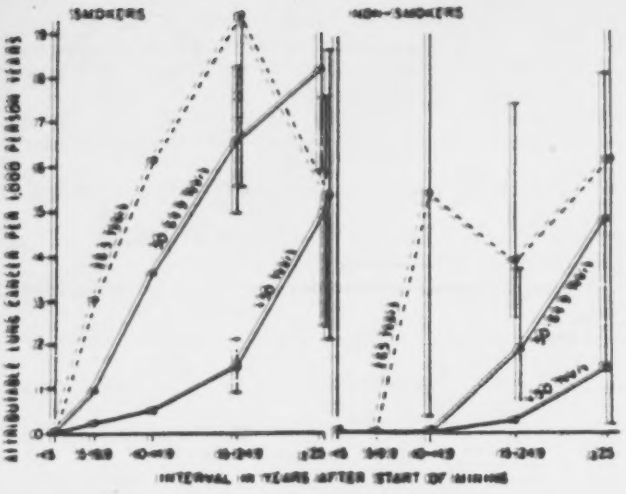

FIG. 3. Lung cancer rates among U.S. white uranium miners by age groups, by smoking, and by interval after start of mining uranium.

have been additive or somewhat more than additive [31–35]. Some were thought to be multiplicative when short-term analyses were done, but none were reported as showing a multiplicative interaction when based on life-span data. These experiments have used mice, rats, hamsters, and dogs and exposed them to either beta or alpha radiation. The one with exceptional results was a dog experiment, in which cigarette smoke reduced the number of LC produced by radon progeny [36]; this result has not been satisfactorily explained.

The hypothetical curves in Fig. 2 are consistent with actual I-L data noted above, with observed changes in LC rates among smoking and nonsmoking miners, and with animal data. They explain very well why different epidemiologists have reported such divergent results with regard to the interaction of smoking and radiation among miners.

An understanding of the nature of the interaction between smoking and radon progeny is quite important for assessing the problem of radon in homes. If the miner data reflects true synergism, the problem in homes should largely disappear as people stop smoking. If the interaction is simply promotive and additive, then the problem will continue and will increase as people live longer and houses are tightened to conserve energy, unless countermeasures are employed.

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HEALTH RISKS OF RADON AND OTHER INTERNALLY DEPOSITED ALPHA-EMITTERS

BEIR IV

Committee on the Biological Effects
of Ionizing Radiations
Board on Radiation Effects Research
Commission on Life Sciences
National Research Council

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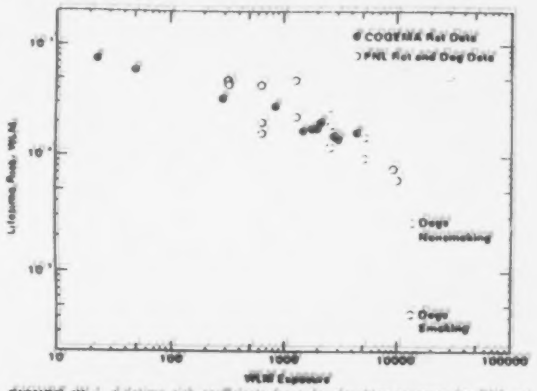

FIGURE III-1 Lifetime risk coefficients for radon-daughter exposure for PNL rat and dog data and COGEMA rat data; error bars are omitted. SOURCE: Personal communication, Dr. F. Cross, Pacific Northwest Laboratories.

LUNG CANCER

In Figure III-1 the mean lifetime lung-tumor risk per WLM (uncorrected for life-span differences from control animals) is plotted against the radon-daughter exposure (WLM) for PNL rats and dogs and COGEMA rats. The higher tumor efficiencies in the PNL studies (in contrast with the COGEMA studies) are probably due to the lower average exposure rates of the PNL experiments.

The uncertainties in the PNL lung-cancer incidence and risk-coefficient data are considered to be due mainly to uncertainties in the exposure data (standard deviations were generally well within ±20% of the means). Whenever PNL exposures were repeated, reproducibility of tumor-incidence data was generally within ±20% of the mean tumor incidence, which included the statistical uncertainties in the exposure data. Because the normal lung-tumor incidence in the absence of appreciable background radon exposures is very low (<0.2%) in the COGEMA and PNL rats, the risk-coefficient data, except for the 20- to 50-WLM COGEMA group of rats, have not been corrected for the incidence in control animals.

Current experiments at PNL, which involve mixtures of radon daughters and uranium-ore dust, will further define the shape of the risk coefficient curve for very low exposures and exposure rates. For the present, COGEMA data on low exposures and low exposure rates indicate a leveling-off of the risk to a value of 6×10^{-4}–8×10^{-4}/WLM.

Kushneva[25] reported that rats given 60 mg of silica by intratracheal with inhalation exposures to radon at 6 pCi/liter developed many non-pulmonary effects, including both abdominal and carcinomas, than control animals exposed to silica alone; the number of tumors and control animals was small. When silica data were included in the exposures, the radon-daughter inhalation studies at COGEMA and PNL showed no increase in tumorigenic efficiency over exposures to radon daughters alone if the exposures exceeded a few hundred WLM. However, in contrast with the rat data of Kushneva[25] and the dog data from PNL, Chameaud et al.[26] have not found the silicotic process to be accelerated by the presence of radon daughters.

Little et al.[9,27] have shown in hamsters that when beagle(s)pyrene and other initiators followed low-dose ^{210}Po instillations, the carcinogenic action of polonium was increased. Because radioactivity appears to be only the initiator of the lung cancer, as in all the animal experiments with radon described here, any later exposure to an irritant that stimulates cell proliferation appears to increase the incidence of cancer.

SUMMARY AND CONCLUSIONS

Laboratory animal research programs on the effects of radon-daughter inhalation are being carried out in laboratories in both the United States and France. While much of the early work explored acute effects, all recent experiments involving chronic exposure have resulted in the induction of lung cancer in both rats and dogs. It should be noted, however, that the location and histopathology of such cancers are not analogous to humans, and caution is warranted in extrapolating from experiments with laboratory animals to humans. Nevertheless, substantial information has accumulated that provides insights into radon-daughter carcinogenesis. Table III-2 summarizes recent findings in animal studies of lung-cancer induction by radon decay products.

In rats, lung tumors have been induced at relatively low exposures (20 WLM).[7] As yet, experiments with dogs do not extend to this low dose range, but tumors have been observed for exposures at the 600-WLM level.[12] It is of interest that lung-cancer incidence in animals increases with a decreasing rate of exposure for fixed cumulative exposure—a finding that has yet to be confirmed in studies of exposed underground miners (Annex 2A). The difficulty of documenting exposure rate for the miners may explain the failure to find a dose-rate effect in the epidemiological studies

TABLE III-2 Summary of Factors Influencing the Tumorigenic Efficiency of Radon Daughter Exposure

Factor	Effect on Respiratory Tract Tumor Incidence
Radon daughter cumulative exposure	Increases approximately linearly with exposure
Radon daughter exposure rate	Increases with decrease in exposure rate (~ 200 to 400% increase from about 500 to 50 WL M/wk)
Radon daughter unattached fraction	Increases with increase in unattached fraction, f_p (~ 50% increase per WL M exposure from 2 to 10% f_p)
Radon daughter disequilibrium	Increases with increase in disequilibrium (~ 10% increase per WL M exposure [borderline significance] from 0.4 to 0.1 equilibrium)
Concomitant exposure to cigarette smoke	Decreases if smoking alternates on same day with radon daughter exposure
	Increases if smoking follows cumulative radon daughter exposure
	No effect if smoking precedes cumulative radon daughter exposure

Large-scale animal studies may become useful for elucidating the interactions between radon daughters and other inhaled pollutants. Information on the extent and duration of smoking is incomplete for human studies, but smoking can be controlled in experiments with animals. It is clear from such experiments that the interactions between smoking and lung cancer induced by radon decay products reflect a complex interplay of these agents in the host. Well thought out experiments with dogs and rats can provide models that aid our understanding of how smoking modulates radiogenic lung cancer. Nevertheless, application to humans is indirect, and confirming experiments with primates may be necessary. However, findings in humans and animals to date are generally parallel for short-half-life radon progeny.

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APPENDIX IV

Epidemiological Studies of Persons Exposed to Radon Progeny

INTRODUCTION

The mining of radioactive ores in the Erz Mountains in eastern Europe was the first occupation associated with an increased risk of lung cancer. Metal ores were mined in Schneeberg, on the German side of the mountains, beginning in the fifteenth century, and in Joachimsthal, on what is now the Czechoslovakian side, beginning in the sixteenth century.[34,35] Both areas were later mined for radioactive ores. As early as the sixteenth century, Agricola[1] described exceptionally high mortality from respiratory diseases in miners in the region. The lung-cancer hazard was first recognized by Harting and Hesse[36] and was reported in 1879. Their report provided clinical and autopsy descriptions of interstitial neoplasms in miners, which they classified as lymphosarcomas. In a work force of about 650 men, Harting and Hesse counted 180 deaths from "miner's disease" between 1869 and 1877; in retrospect, most of these deaths were probably from lung cancer. During the early twentieth century, histopathological review of a series of cases established that the malignancy prevalent among miners in the Erz Mountains was primary cancer of the lung.[37,38]

The problem was not recognized in the miners on the Czechoslovakian side of the Erz Mountains until 1929, when two cases of lung cancer were reported in Joachimsthal miners. In 1932, Fischer and Sikl[39] described the autopsy findings in nine miners with lung cancer. There were 9 miners with cancer among 19 miners in Joachimsthal who died during 1929-1930. Formal epidemiological studies of the Schneeberg and Joachimsthal miners were not carried out, but published reports documented that about 50% of the miners eventually died from lung cancer.[35] Peller[34] calculated lung-cancer

TABLE IV-1 Results of Colorado Plateau Study (Summarized from Principal Reports) of Male Uranium Miners

Follow-up Until Date	No. of Subjects	No. of Lung Cancer Deaths (Observed/ Expected)	Comment	Reference
1950	2,340	6/3 [illegible]	Increase not statistically significant	2
1950	987	5/1.3* [illegible]	Cohort members with at least 3 yr of experience	2
1952	3,656	15/4.2* [illegible]	Includes 1.1% workers with surface, open pit, or occasional underground work, respectively, through 1960	65
1963	3,415	22/5.7* [illegible]	Response increases with cumulative WLM	66
1967	3,414	62/10.8* [illegible]	Excess lung cancer in all exposure categories from < 120 WLM to 3,720 WLM	32
1968	3,366	70/11.7* [illegible]	Most comprehensive report	33
1976	3,366	104/29.8* [illegible]	Response increases with cumulative WLM in all smoking groups	4
1977	3,362	185/38.6* [illegible]	WLM still considered in analysis	67

*$P < 0.05$
**$P < 0.01$
†SMR is 482, 95% lower confidence limit is 425.

TABLE IV-2 Chronology of Radon and Radon Daughter Measurements in Colorado Plateau Study*

Time	Source and Type of Measurement
Before 1950	Few radon measurements, earliest 1949
1950	Few radon samples by the PHS and Colorado State Health Department
1951	Radon and radon-daughter samples by PHS, state agencies, and U.S. Bureau of Mines
1952	Radon and radon-daughter samples taken by PHS in attempt to survey all mines
1953–1954	Scant data collection by PHS and state; data used to survey every mine
1955	Some PHS coverage; variable among mines; mining companies begin measurements
1956–1958	Mine survey work primarily by companies
1959–1960	Colorado, Utah, and New Mexico combined survey; company measurements continued
After 1960	State and mining company programs

*Based in part on Lundin et al.[34]

exposed at the concentrations indicated by the measurements were not uniform. The arithmetic average could also be strongly influenced by outlying high values.

To calculate WLM, the WL estimates were combined with work-history information obtained from annual censuses of active miners and from questionnaires. Apparently, a 170-h work month was assumed, and time for vacations, sick leave, or other absences from work was not subtracted from the number of underground hours estimated from the work history.[63] However, cumulative exposures were also not adjusted for time worked beyond 170 h/month, a common practice in the early years of the industry.[63] The investigators did not have enough information to consider work location within a specific mine or job classification, which might have influenced ventilatory demands.

Because WL measurements were sparse in relation to the numbers of mines that were worked, the WLMs accumulated by most miners were based on both measurements and estimates. In fact, WLM totals were calculated solely from measurements on only 10.3% of the white miners. For 36.1% of the white miners, some type of estimation was involved in the calculation of all WLM values; for the remainder, some WLM estimates were based on WL values derived by one of the estimation procedures.[63] In reports published to date, the WLM estimates have extended through September 1969. Information on cigarette smoking was obtained during the survey examinations, at the annual censuses of miners, and from mailed questionnaires.[63,66] As described by Whittemore and Mckhann,[67]

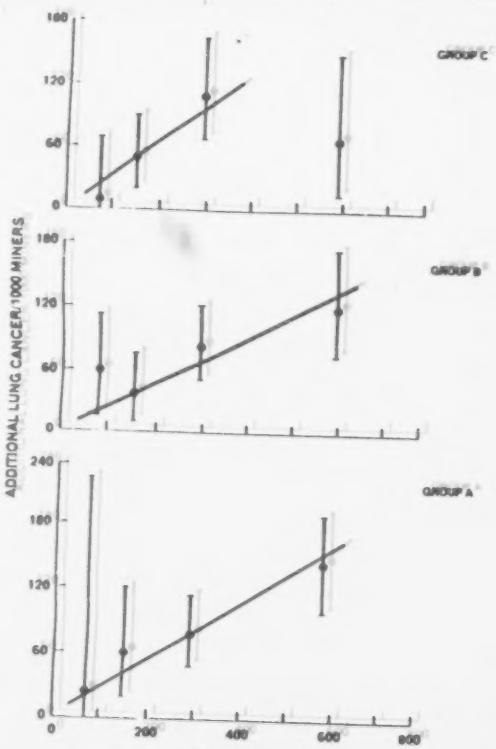

FIGURE IV 2 Relation between additional lung cancer frequency and cumulative radiation exposure in three groups of Czechoslovakian uranium miners by time course of exposure accumulation (see text) SOURCE Kunz et al[29]

follow-up or on the percentage of death certificates not obtained. However, on the basis of a sample of known deaths, 0.3% were not identifiable as deceased with the same follow-up method. Death certificates were the only source of information on cause of death.

Using the modified life-table technique, Muller et al.[30] compared observed with expected mortality (based on the Ontario general male population rates with adjustment for age and calendar period). Results for causes of death other than lung cancer were available only for 1955–1977. The authors did not have information on cigarette-smoking habits of the miners.

The mean cumulative WLM of miners with no previous gold-mining experience was 40 (lower estimate) to 98 (upper estimate). All other descriptions of the cohort included those who had previously mined gold. The median year of birth of the cohort was 1921, and the median year first employed in a mine in Ontario was 1947; thus, the median age at first employment in a mine in Ontario was probably about 26 yr. The median duration of work in a mine was 1.8 yr.

Among uranium miners without any gold-mining experience, Muller et al.[30] found that observed to expected ratios for lung-cancer deaths increased across the six categories of cumulative WLM (Table IV-9). When the upper estimated exposures were used, the first definite excess occurred at a cumulative WLM of 100–170 (mean, 130), with 14 observed and 9.9 expected lung cancers. When the lower estimated exposures were used, there was a definite excess at a cumulative WLM of 60–70 (mean, 83), with 13 observed and 7.0 expected lung cancers. Muller et al.[30] reported that linear regression of the dose-response relationship, weighted by number of person-years at risk (PYAR), showed similar fits for the excess and relative-risk models.

A 5- and 10-yr exposure lag did not change the slope of the relative-risk model (0.5% excess relative risk per WLM for the upper exposure estimates and 1.3% for the lower ones), but slightly increased the slope of the excess-risk model (from 4.3 to 7.2/million WLM for the lower exposure estimates and from 2.0 to 2.8 for the upper ones). With either model, the use of the upper exposure estimates decreased the dose-response slope by more than 50%. However, dose-response analysis for ten age groups of PYAR indicated that the slopes for the relative-risk model were age-independent, whereas the slopes for the excess-risk model were not.

ELDORADO URANIUM MINERS

Howe et al.[26] conducted a retrospective cohort mortality study of all 10,945 male employees who had worked at the Eldorado Uranium Mine in Beaverlodge, Saskatchewan, anytime between 1948 (when the mine opened) and December 31, 1980. The cohort was identified from company employment and payroll records. The final study group included

TABLE IV-7. Lung Cancer Among Czechoslovakian Uranium Miners in Relation to Cumulative Radon-Daughter Exposure[a] Based on "Modified Life-Table Method"[b]

Cumulative WLM	No. of Person-Years at Risk	Calculated No. of Lung-Cancer Deaths/10,000 Person-Years			
		Observed (95% Confidence Limits)	Expected	Additional (Observed − Expected)	Observed/Expected Ratio
<100	9,380	(2.3)= 0.6–13.9)	5.5	0.9	1.2
100–199	10,137	(19.7)–36.8–133.8)	7.6	17.2	3.3
200–399	19,614	(36.0)–42.8–152.4)	9.7	33.1	5.6
≥400	11,830	(54.8)–69.2–245.3)	8.4	60.9	8.2
Total	50,913	(36.7)–47.2–167.3)	9.3	39.9	5.0

[a]Start of exposure was 1948–1952; the cutoff date for analysis was December 31, 1973.
[b]Based on data from Kunz et al.[9]

TABLE IV-12 Standard Mortality Ratios for Lung Cancer among Colorado Employees[a]

Site	No. of Lung Cancer Deaths		
	Observed	Expected	SMR
Bruceladge	112	98.87	104
Port Hope	14	17.16	82
Port Radium (surface)	20	15.93	175
Port Radium (underground)	55	16.67	375
Other sites	5	4.53	110

[a]Based on data from Roe et al.[56]

of 0.22. The only epidemiological results were for lung-cancer mortality: 30 observed versus 16.77 expected among the entire cohort without allowing for exposure or latency considerations. No dose-response results were reported. It appears that PYAR for each miner began inappropriately at the date of first employment and not after 3 months of mining. National mortality rates were used for comparison; however, the miners are all in agricultural areas. The WLM data in this study are potentially limited by the lack of measurements for 1947-1955 and the retrospective estimation of the equilibrium factor. Furthermore, cause of death was not known for 25% of the deceased subjects.

CORNISH TIN MINERS

High concentrations of radon and its daughters have been measured in tin mines in Cornwall, England. Fox et al.[57] conducted a retrospective cohort study of mortality in 1,222 men employed in two tin mines in Cornwall during 1939. In comparison with mortality rates for England and Wales, lung-cancer mortality was increased in the underground miners (SMR, 271), but not in surface workers (SMR, 74) or in workers who were not classifiable into either of these two categories (SMR, 94). WLM were not estimated for the subjects. The authors reported government estimates of 25 WLM and 15 WLM, respectively, annually for the two mines.

CHINESE TIN MINERS

Tin has been mined in the Yunnan region of China for centuries,[92] and the miners in this region are known to have uranium and radon-daughter exposures. Wang et al.[58] identified a cohort of 12,247 underground miners

TABLE IV-13 Lung-Cancer Mortality by Cumulative Radiation Exposure among Chinese Tin Miners[a]

Cumulative WLM	No. of Person-Years at Risk	No. of Lung Cancer Deaths		Observed/Expected Ratio
		Observed	Expected	
<140	33,302	31	7.1	4.4
140-279	20,040	40	6.0	7.1
280-559	19,111	105	8.2	13.0
560-839	6,038	92	3.8	24.2
840-1,399	7,845	115	3.7	30.7
≥1,400	1,779	45	1.0	43.6
Total cohort	88,120	428	29.8	14.5

[a]Based on data from Wang et al.[58]
[b]Based on Shanghai population, approximately constant adjustment for age, sex, calendar period

and followed them from 1976 to 1987 for lung-cancer incidence and mortality. Information has not been reported on the selection of study subjects, their duration of work, latency distribution, smoking distribution, follow-up methods, or losses to follow-up. The last date of entry of the cohort was not given, but it has been reported that many persons began underground mine work between the ages of 8 and 14 years, with practice with blasting not around 1940. WLM were estimated from detailed individual work histories and systematic radon-daughter measurements in underground work areas during 1972-1987. Only indirect estimates were used in the mines in 1953-1972, as exposures were assumed to be constant during this interval. Before 1953, most of the mines were inactive, and only talking methods were used, and proportionate adjustments were made. Another adjustment was made for exposures before 1960, when more primitive mining methods, including back-carrying of ore through narrow tunnels, were used.

During the follow-up period, lung-cancer incidence was 511/100,000 (499 cases) among underground miners, 413/100,000 (39 cases) among surface workers. The investigators did not report the incidence data by dose, years worked, or latency. Lung-cancer mortality for the underground miners was also compared with that of the Shanghai population (Table IV-13), but apparently without adjustment for age, sex, calendar period, or smoking.

In addition to radon daughters, exposure to arsenic was considered to play an etiological role in the lung-cancer excess. Ore samples contained 1.5-3.5% arsenic; the investigators estimated that a miner's respiratory

has been demonstrated, with different radium concentrations in soil and building materials and different air-exchange rates largely explaining the size of the range.

Epidemiological investigations of domestic radon progeny as a risk factor for lung cancer are still preliminary. Both descriptive and analytical approaches have been used to examine the association between radon-daughter exposure in the home and lung cancer. Techniques for estimating lifetime exposure of people to radon daughters from indoor air are not yet available, and surrogates based on residence type or a few limited measurements have been used in the analytical studies. The available studies are insufficient for the development of quantitative risk estimates for associating exposure to radon progeny in the home and lung cancer.

In the descriptive studies, incidence or mortality rates for lung cancer within geographic units have been correlated with measures of exposure for inhabitants of the units. Edling[50] compared mortality rates for different Swedish counties with background gamma radiation, described as being correlated with indoor exposure to radon and its daughters. For lung-cancer mortality, the correlation coefficients were 0.46 for males and 0.55 for females. Hess and colleagues[20] performed a similar analysis for lung-cancer mortality during 1950-1969 in the 16 counties of Maine. Using average radon concentrations in water as the measure of exposure, they calculated correlation coefficients of 0.46 for males and 0.65 for females. In a study of 28 Iowa towns served by deep wells, lung-cancer incidence increased with the concentration of ^{226}Ra, a possible surrogate for the radon concentration in the water.[9] These descriptive studies, which did not consider the exposures of people to radon daughters and other agents, provided only suggestive evidence that radon progeny exposure in the home increases lung-cancer risk.

The association has been more directly tested in case-control and cohort studies. Axelson et al.[6] conducted a case-control study in a rural area of Sweden. The investigation included 37 cases and 178 controls. Exposure to radon progeny was inferred from the characteristics of the subjects' residences at the time of death. Those who lived in stone houses were assumed to be most heavily exposed to radon daughters, and those who lived in wooden houses were assumed to be least exposed; other types of dwellings were considered to be sources of intermediate exposure. In spite of the crudeness of this exposure classification, residence in stone houses was associated with a significantly increased odds ratio, in comparison with the reference category of wooden houses (by Mantel Haenszel method, odds ratio, 5.4; 90% confidence interval, 1.5–19). Data concerning cigarette smoking and residence history were not obtained.

Edling and Axelson[50a] conducted a similar case-control study in a rural area of Sweden. The study subjects were residents of the island of Oeland who died during 1965–1978. The geological characteristics of this island were thought to result in strong differences in background radon concentrations within a small area. Included in the study population required at least 30 yr of residence on the island before death; 77 lung-cancer cases and 308 controls who died from causes other than lung cancer met this criterion. Most of the dwellings were monitored for radon daughters during 3 months of summer and 1 month of winter. The dwellings were also classified on the basis of structural characteristics, as in the earlier study by Axelson et al.,[6] and cigarette smoking information was obtained from next of kin. Lung-cancer risk was significantly associated with radon-daughter exposure, as indexed by either the measured concentration or the characteristics of the dwelling, and both crude and smoking-adjusted risk estimates were significantly increased. Logistic analysis yielded smoking-adjusted odds ratio, comparing most with least exposed, of 3.9, and the 90% confidence interval was 1.6–10.0.

Pershagen et al.[50b] reported the findings of two small case-control studies in Sweden on domestic radon-daughter exposure, one drawn from a larger study in northern Sweden and the other from a twin registry. The investigators identified cases who were 30 case-control pairs, divided equally between matched and unmatched. Exposure to radon was estimated from information on dwelling type; the investigators attempted to consider all residences lived in by the subjects. In the study group from northern Sweden, imputed radon exposures were significantly higher in smokers than in their matching controls. Estimated exposures to radon progeny were similar in the nonsmoking cases and controls in the series from northern Sweden and in the matching and nonmatching cases and controls in the second series (selected from the twin registry).

In the United States, Simpson and Comstock[50c] examined the relationship between lung-cancer incidence and housing characteristics. During a 12-yr period in Washington County, Maryland, lung-cancer incidence was not significantly affected by the type of basement construction or building materials. No measurements of radon or its daughters were made. Rather, dwelling-related variables were assumed to be surrogates for radon-daughter exposure.

SUMMARY

Cause-specific mortality risks for a number of the minor groups discussed above are listed in Table IV-10. Without exception, these studies

TABLE IV-16 Cause-Specific Risks of Mortality among Miners Exposed to Radon Daughters[a]

Study	All Causes			Lung Cancer			Tuberculosis			Other NMRD			Neoplasms and Neoplasms[b]		
	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR
Colorado Plateau Uranium Miners[20]	490	600	136	185	38.4	482	14	3.4	409	83	16.6	499	9	3.7	243
Ontario[21,22]	1,216	1,113	116	119	65.8	181	4	3.9	132	18	49.5	195			
Elliot Lake Ontario Uranium Miners[23]	999	884	117	81	50	162	1	2.3	44	13	7.2	180			
Beaverlodge Ontario Uranium Miners[24]	244	203	120	30	12.4	241	2	0.6	333	4	1.8	215			
Eldorado and Ontario[25]	198	116	171	33	7.2	458	1	0.4	250	2	1.0	200			
Eldorado-Port radium[26] underground surface	361 240	225 239	160 121	53 28	14.7 16.0	375 175	3 4	1.7 1.8	176 0	3 0	4.4 5.6	68 143	2 0	1.0 1.2	199
Eldorado Beaverlodge[27] underground surface[27] uranium miners[28]	600 515 <600	487 339 382	123 97 156	64 29 <5	20.0 30.6 34.2	320 91 <40	1 3	2.8 3.0	36 100	4 4	8.5 10.4	71 97	3 1	2.1 2.3	140 44
Swedish iron miners Malmberget[29]	522	409	130	80	14.6	547									
Norwegian niobium workers[30]	78	67.6	115	12	3.0	405									
Newfoundland fluorspar miners (1950-1976)[31]	244	173	(141)	45	9.5	1,200	249	4.4	550	19	5.1	167	1	2.0	50
Cornish tin miners underground surface[32]	776	—	183	38	—	211	39	—	—	41	—	—			
Colorado Plateau uranium miners[20]	9	4.9	150	1	3.0	33	5	2.3	216	1	0.6	153	0	12.0	75
Ontario[21,22]	21	16.1	130	0	5.8	104	4	4.9	82	2	1.4	145	26	27.4	95

TABLE IV-16 (Continued)

Study	Stomach			151[c]			Kidney 189[d]			Skin 190, 191[e]			Bone 196[f]			Lymph. and Hemo. 200-205		
	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR
Elliot Lake Ontario uranium miners[23]	15	12.2	131	4	4.4	90	2	1.1	187	22	21.1	104						
Beaverlodge Ontario uranium miners[24]	4	3.1	129	2	1.1	180	1	0.2	522	0	0.2	0	0	0.1	0	2	4.0	
Eldorado and Ontario[25]	4	1.8	219	0	0.6	0	0	0.3	0	0	0.1	0	0	0.1	0	2	2.7	74
Eldorado-Port radium[26] underground surface	5 2	4.2 0.3	119 [redacted]	1 2	1.3 1.4	79 [redacted]	1 0	0.7 0.7	147 0	0 0	0.3 0.3	0 0	0 0	0.3 0.3	0 0	10 14	9.4 11.6	107 121
Eldorado Beaverlodge[27] underground surface[27] uranium miners[28]	10 0 *	8.4 9.3	120 0.4	2 1	2.6 2.7	76 38	0 2	1.6 1.6	0 127	0 1	0.6 0.7	0 140	0 1	0.6 0.7	0 140	4 13	17.6 21.3	31 61
Swedish iron miners Malmberget[29]	28	18.1	159													*9	4.7	149
Norwegian niobium workers[30]	1			1			0			0								
Newfoundland fluorspar miners (1950-1976)[31]	24	13	(180)															
Cornish tin miners underground surface[32]	10	—	200															

[a]Abbreviations: Obs., observed; Exp., expected; NMRD, Non-malignant Respiratory Disease.
[b]Numbers are disease classifiers from ICD. [c]Uranium.
[d]Including pervious gold miners, excluding Eldorado uranium miners.
[e]Lymphoma only
[f]No significant excess.
[g]Digestive system.
[h]Includes silicosis
[i]Respiratory disease.
[j]Cerebrovascular disease.
[k]Also tuberculosis.
[l]Silicosis cases

indicate an excess probability of death due to lung cancer and, in many cases, other causes of death as well. Continued follow-up of these miner groups will provide additional information on the association of radon-daughter exposure to lung cancer and perhaps other diseases. As discussed in Chapter 2 and Appendix VII, epidemiological information that includes the smoking status of each participant is of paramount value. The committee suggests that every effort be made to collect and report such information for the studies described in this appendix.

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APPENDIX V
Nonmalignant Respiratory and Other Diseases Among Miners Exposed to Radon

Epidemiological evidence on radon progeny as a potential risk factor for nonmalignant respiratory disease is restricted to uranium miners. As discussed in Appendix III, animal studies are consistent with an association between exposure to radon progeny and nonmalignant respiratory disease. Animals so exposed develop emphysema and interstitial fibrosis. Pulmonary fibrosis and, to a lesser extent, emphysema are common findings in hamsters, rats, and dogs exposed to radon progeny alone and in mixtures with uranium-ore dust.[1-5,10] These effects are not produced to any appreciable extent in groups of animals until exposures to radon daughters exceed several thousand working-level months (WLM). Thus, the clinical diseases of interest are chronic obstructive pulmonary disease, in which airflow obstruction results from emphysema and airway changes, and interstitial processes such as pulmonary fibrosis.

The occurrence of nonmalignant respiratory disease has been examined in miners from the Colorado Plateau region and from Ontario, Canada. Several reports from the U.S. Public Health Service study described excess mortality from nonmalignant respiratory disease.[4,66] Between 1950 and 1977, a fivefold excess of death occurred from nonmalignant respiratory disease, exclusive of tuberculosis, bronchitis, influenza, and pneumonia.[4] Causes of death were primarily emphysema, fibrosis, and silicosis. The effects of cigarette smoking were not considered.

In the Ontario miners, mortality from influenza, pneumonia, bronchitis, and asthma was not increased. However, mortality from silicosis and chronic interstitial pneumonia was significantly elevated (11 deaths observed, with 2.14 expected).

As part of the U.S. Public Health Service study of Colorado Plateau miners, physical examinations and lung function testing were performed in 1957 and 1960.[7] Data were collected for 2,149 white males, but only 277 participated in both years. Spirometry was carried out at both examinations, and the peak expiratory flow rate was measured in 1960. Three different measures of radiation exposure were used: (1) years of underground uranium mining, (2) a radiation index based on the working level at the time of examination, and (3) a cumulative, ordinal measure of exposure. The analyses were interpreted as showing loss of ventilatory function with increasing cumulative exposure. However, the data were neither collected nor analyzed with techniques that are currently accepted for lung function parameters. Further, the accuracy of the exposure measures that were used is uncertain.

In a later paper, Archer et al.[8] used the same U.S. Public Health Service study data and demonstrated an increasing prevalence of emphysema, as diagnosed by a physician's examination, with increasing WLM. However, the diagnosis of emphysema, a histopathologically identified disease, cannot be established by physical examination. Trapp et al.[22] performed more detailed studies on Colorado Plateau uranium miners and found evidence of pulmonary dysfunction, both restrictive and obstructive. The design of the investigation did not permit assessment of exposure-response relationships with lung function measures.

More recently, Samet et al.[20] surveyed 192 long-term New Mexico uranium miners. The survey procedures included spirometry, completion of a respiratory symptoms questionnaire, physical examination of the chest, and interpretation of chest x rays. Total duration of underground uranium mining, not WLM, was used as the exposure index. The design of the investigation did not permit assessment of the effects of each potentially hazardous agents as radon daughters, silica, and diesel exhaust. With linear multiple-regression analysis that controlled for cigarette smoking, duration of mining was associated with reduction of the forced expiratory volume in 1 s and reduction of the midmaximum expiratory flow rate, but not with reduction of the forced vital capacity. Chest x-ray abnormalities compatible with silicosis were found in 9% of the uranium miners examined for this survey.

These investigations have not separated the effects of radon-daughter exposure from those of other atmospheric contaminants, such as silica, diesel-engine exhaust, and blasting fumes, found in a uranium mine. Given the inadequacies of available exposure data, epidemiological methods cannot assess the individual contributions of all harmful agents to which uranium miners are exposed or are potentially exposed.

OTHER DISEASES AMONG MINERS EXPOSED TO RADON PROGENY

Mortality from selected causes among miners exposed to radon daughters is detailed in Appendix IV, Table IV-16. In addition to the excess risk from lung cancer, a number of the mining cohorts have experienced an excess risk of mortality due to tuberculosis and to "other nonmalignant respiratory diseases," (ICD Code 510-527, 7th revision). Because of the past levels of silica in the mine atmospheres, most of these excesses are believed to be due, in fact, to silicosis, which has been often diagnosed on death certificates as silicotuberculosis, tuberculosis, or other forms of nonmalignant respiratory disease.

Results from many studies of the mining populations have suggested that there is a slight excess risk of stomach cancer, which has an elevated incidence among other mining groups, including gold miners in Ontario without uranium mining experience[10] and coal miners in the United States.[11] Among the Ontario uranium miners, no excess risk existed for those without prior gold mining experience (9 observed versus 9.55 expected).[17] The cases are few, and the risks are low in most studies, but the occurrence of this excess risk in eight different mining populations lends credibility to the causative hypothesis that the excess has resulted from a common occupational risk factor. From the reported analyses, however, it is difficult to determine if that risk factor is radon progeny because exposure-response analyses have not been reported.

Two studies, both based on small numbers, have found nonsignificant excesses of skin cancer. While Sevc and et al.[21] found that basal cell carcinomas predominated, four of the five miners in the Colorado Plateau study who died of skin cancer had melanomas.[24] Since the other mortality studies have not shown any significant skin-cancer excess, it is unlikely that alpha radiation in the mines accounted for these excesses. However, the occurrence of skin cancers, particularly nonmelanomas, cannot readily be evaluated with a mortality study. Most skin cancers other than malignant melanoma can be readily cured and rarely lead to death. No other sites of malignancy appear to be consistently elevated among these mining populations. Despite the fact that airborne radon daughters deposit in the nasal passages, no cases of nasal cancer have been reported in any of the epidemiological studies. Only Muller et al.[17] reported an expected value of 0.8 for nasal cancer mortality among all Ontario uranium miners.

Excess risk of mortality due to nonmalignant renal disease was found in a recent analysis of the Colorado Plateau study.[24] In that survey, chronic and unspecified nephritis was particularly elevated after 10 yr latency (7 observed versus 1.9 expected; standardized mortality ratio, 362). The committee considered that this excess may be either a chance

finding or indicative of an occupational risk factor, possibly alpha radiation or uranium. The nephrotoxicity of soluble uranium in animals is well documented in the experimental literature,[74] but most of the uranium in mines occurs as less soluble oxides.

Findings from relevant animal experiments should also be considered in interpreting the epidemiological data. In radon-daughter-exposed animals, lesions observed in organs other than the lung are considered spontaneous, or only indirectly exposure-related, in contrast to the case for most alpha-emitters, which translocate from the lung to irradiate other organs. Because of the extremely short half-life of the radon daughters, their alpha emissions occur before they move to other organs. In animals exposed to high concentrations of uranium-ore dust alone (and presumably to radon daughters and uranium-ore dust mixtures) sufficient long-lived radioactivity from the precursors of radon can concentrate in the kidneys to impair their function. However, direct evidence of renal function impairment from exposure to radon daughters alone is lacking.

CYTOGENETIC STUDIES

The frequency of chromosome aberrations in blood cells has been examined in uranium miners and other underground workers as a marker of injury due to ionizing radiation. Brandom and colleagues[5,6] have reported on chromosome aberrations in uranium miners from the Colorado Plateau region of the United States. In their 1972 report,[5] cytogenetic abnormalities in peripheral lymphocytes from 15 miners were compared with the findings in 15 age-matched nonminer controls; 5 of the miners had lung cancer at the time of the study. Most of the aberrations were more prevalent in the miners, and many of the differences between the two groups attained statistical significance.

A subsequent report by Brandom et al.[6] included 80 underground uranium miners and 20 controls, frequency-matched for age and smoking habits. Again, the various types of chromosomal aberrations were more prevalent in the uranium miners than in the controls. Exposure-response relationships were evident up to a cumulative exposure of 3,000 WLM; however, chromosomal abnormalities were less frequent in those with greater than 3,000 WLM than in those with 1,740–2,890 WLM, the next lowest exposure category.

Badgastein is a spa in Austria with thermal springs that discharge water with a high concentration of radon. At Badgastein, patients are also treated in a former gold mine that has a mean radon concentration of 3,000 pCi/liter. Pohl-Ruling and Fischer[19] evaluated cytogenetic abnormalities in inhabitants of the community, bath attendants, and personnel exposed underground. The investigators estimated blood doses from alpha and gamma radiation and used the dose estimates for assessing dose-response relationships. The analyses did not provide a clear estimate of the effect of alpha radiation, though they concluded that occupational alpha doses flattened the dose-response relationships for radiation.

Relevant data are also provided by a study of cytogenetic abnormalities in persons presumed to be exposed to high concentrations of radon in household water.[77] Chromosome aberrations were evaluated in 18 exposed persons and 9 controls. Dicentrics, chromosome breaks, and cells with chromosome change were significantly more frequent in the 18 exposed subjects. However, exposures to radon daughters were not estimated, and the suitability of the control group was not satisfactorily established.

To date, only the above-mentioned limited data are available on cytogenetic abnormalities in radon-daughter-exposed populations. The study of Colorado Plateau uranium miners indicates exposure-response relationships for chromosome aberrations. However, confirming evidence is not available from other populations, and the biological significance of these observations has not been established.

EFFECTS ON REPRODUCTIVE OUTCOME

Recent and primarily descriptive data have renewed speculation that uranium mining is associated with adverse reproductive outcomes. Muller and colleagues[17,18,19] made the first reports on this subject in a series of papers on Czechoslovakian uranium miners that were published during the 1960s. For 1,000 underground male workers, the numbers of children in relationship to age did not deviate from that expected from nationwide data.[17] However, in this sample and in another with 415 uranium miners,[18] the secondary sex ratio (male to female births) declined following the start of underground employment from 1.08 to 0.85 in the former sample and from 1.18 to 0.99 in the latter.

Potential reproductive effects of uranium mining received little further evaluation until the early 1980s. At that time, descriptive data from New Mexico were interpreted as suggesting the adverse reproductive effects caused by uranium mining, by affecting either uranium miners or those living in the vicinity of mines and mills.[27]

This more recent interest in reproductive effects caused by uranium mining followed reports of high rates of congenital malformations and spontaneous abortion at the Shiprock Indian Health Service Hospital, located in San Juan County, New Mexico, which serves Navajos in the northeastern portion of the Navajo nation. Goodman subsequently examined the secondary sex ratio in New Mexico and Navajo births.[27] He analyses showed a temporal decline in the secondary sex ratio for New Mexico, in comparison with nationwide data, that occurred during the period of

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APPENDIX VI
Lung-Cancer Histopathology

Correlations between radon-daughter exposures and specific histopathological cell types of lung cancer in humans have been a subject of controversy for many years. Primary cancer of the lung comprises diverse and generally distinct histopathological cell types. The most common are squamous-cell carcinoma, small-cell carcinoma, adenocarcinoma, and large-cell carcinoma, representing, respectively, about 35, 17, 25, and 9% of lung cancers in the male population of the United States.[19] In nonsmokers, adenocarcinoma is the most common cell type and small-cell carcinoma is infrequent, accounting for less than 6%.[20] Clinically, these four cell types of lung cancers differ in their manner of clinical presentation, natural history, and response to therapy. At present, lung cancers are generally classified histologically by conventional light microscopy. Figure VI.1 shows examples of some of the common histological types of lung cancer. Numerous classification schemes have been published, with the most widely used being that developed by the World Health Organization and recently modified.[20] The accuracy of histopathological diagnosis is influenced by the quantity and quality of the tissue available for examination. Observer variability in the classification of lung-cancer histopathology has been well documented and may be of substantial magnitude.[14] Reliance on clinical reports may introduce substantial misclassification. Because of observer variability, classification of lung-cancer cell types for research purposes should incorporate a standardized review of original histological material by a panel of pathologists. However, use of review panels does not ensure comparability between studies.

extensive uranium mining in the state. The decline in secondary sex ratio was greatest for counties with mining activity; further, the Navajo Area Indian Health Service units with the lowest sex ratios also encompassed areas of mining. A preliminary study of Grants, New Mexico, area miners also suggested effects on the secondary sex ratio, and a study of 11 miners showed distribution of Y bodies in their sperm different from that in control populations.[19]

Waxweiler and Roscoe[25] reviewed the results of a 1965 questionnaire survey of Colorado Plateau miners; overall, the secondary sex ratio did not vary with cumulative WLM. When the participants were stratified at the population's median age of 24, the secondary sex ratio was significantly increased in the highest exposure category. This observation could not be readily explained.[1,26]

Two studies were implemented to follow up on these hypothesis-generating observations: a survey of reproductive outcomes in wives of Navajo uranium miners and a case-control study of births at the Shiprock Hospital. Wiese and Skipper[26] have recently reported preliminary findings of the survey of reproduction outcomes. Questionnaires were distributed to uranium miners in the Grants, New Mexico, area and to potash miners employed in the southeastern portion of New Mexico. The study population included 491 uranium and 220 potash miners. The investigators did not find significant differences between the two groups in the frequency of low birth weight infants, sex ratio, miscarriages, or infertility. Birth weights were lower in children born after the men began underground mining, but the effect was present only in those births after 1970, when average exposures to radon daughters were lower in the mines. Findings from the case-control study in Shiprock have not yet been reported. To date, the evidence on the possible reproductive effects of uranium mining is largely descriptive and preliminary. The studies of uranium miners do not show a consistent and readily interpretable pattern of effect. The data related to possible effects of the uranium mining industry on the general population are fragmentary at present.

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Lung Cancer Among Navajo Uranium Miners*

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Lung cancer has been a rare disease among the Indians of the southwestern United States. However, the advent of uranium mining in the area has been associated with an increased incidence of lung cancer among Navajo uranium miners. This study centers on Navajo men with lung cancer who were admitted to the hospital from February 1965 to May 1979. Of a total of 17 patients with lung cancer, 16 were uranium miners, and one was a nonminer. The mean value of cumulative radon exposure for this group was 1139.5 working level months (WLMs). The predominant cancer type was the small cell undifferentiated category (62.5 percent). The low frequency of cigarette smoking in this group supports the view that radiation is the primary cause of lung cancer among uranium miners and that cigarette smoking acts as a promoting agent.

The association between uranium mining and lung cancer is well established today. The relationship between lung disease and mining was recognized in European studies as early as the 16th century.[1] Subsequent reports confirmed those early observations and attributed pulmonary malignancies to high radiation levels found in the mines.[2,3]

With the onset of intensive uranium mining in the United States in 1948, a similar risk of lung cancer associated with radiation was suspected. The risk was especially enhanced when excessive radon concentrations existed in the mine air.[4] Other research data on the miners have indicated that their risk of lung cancer is related to the magnitude of exposure to radon daughters.[5,6] Moreover, a recent study clearly demonstrated an excess of lung cancer among the white and Indian uranium miners of the southwestern United States.[7]

Numerous reports have largely attributed the etiology of lung cancer among uranium miners to radiation.[7,8] Another study, however, has suggested that the leading cause of lung cancer in uranium miners is cigarette smoking, since the incidence of lung cancer in noncigarette smokers is "insignificant."[9]

To cast more light on the controversy of cigarettes vs radiation in the causation of lung cancer, a number of Navajo uranium miners were studied, since they represent a singular group who smoked few cigarettes and had a very low rate of lung cancer before the advent of uranium mining.

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Materials and Methods

The Shiprock Indian Health Service Hospital and the Navajo Family Health Center are situated in the Four Corners area (New Mexico, Arizona, Utah, and Colorado). These facilities provide medical care to approximately 23,000 Navajos. This population includes many former and present uranium miners.

All male Navajo miners and nonminers with lung cancer admitted to the hospital between February 1965 and May 1979 constitute the basis for this report. Verification of occupation, radiation exposure records, and time spent in the mines was furnished by the National Institute for Occupational Safety and Health and the Center for Disease Control at Salt Lake City. Smoking histories were obtained from patients' charts. Diagnosis of lung cancer and cell type were established by biopsy, bronchoscopy, thoracotomy, or autopsy. The induction-latent period (time from onset of mining to diagnosis of cancer) was determined for each miner. Age at and date of death were obtained from hospital records and death certificates.

Data on cumulative radon daughter exposure are expressed as working level months (WLMs). One working level (WL) is equivalent to 1.3×10^5 MeV of potential α energy from radon daughters per liter of mine air. WLMs are the cumulative underground exposure in working months (170 hours) times concentration of radon daughters in WL specific for mine and calendar year.

Results

Tables 1 and 2 summarize the data for each miner. Of the 17 male Navajo patients with lung cancer admitted during the period February 1965 to May 1979, 16 (94.1 percent) were uranium miners; one (5.8 percent) was a nonminer (a former carriage-maker). Most of the uranium miners had also worked intermittently as shepherds and farm laborers.

The mean value of cumulative radon daughter exposure for the miners was 1,139.5 WLM, ranging from 38.8 to 2,125 WLM. The values for WLM were partly based on estimates. The mean length of time of exposure in the mines was 11.9 years, ranging

standards in the early days of the uranium mining industry.[6]

The hazardous levels of radiation existed until American scientific studies, concurring with European data, reported the association of lung cancer with high radiation levels in uranium mines. Wagoner and his associates[15] in 1965 reported that the incidence of lung cancer increased from 3.1 per 10,000 miners per year to 116.1 per 10,000 miners per year over six exposure categories, ranging from fewer than 120 WLM to more than 3,720 WLM. Lundin and his group[5] described an excess of lung cancer in uranium miners within the range 120 to 359 WLM. The doubling dose for the induction of lung cancer among uranium miners has been estimated at 120 WLM or 240 rads (1 WLM is equivalent to between 1 and 5 rads).

In this study, the mean cumulative radiation exposure was 1,139.5 WLM. Previous reports[5-15] have shown a notable excess in incidence of lung cancer associated with high radiation levels at this range. The highest incidence of lung cancer is occurring now in those miners who were exposed to cumulative radiation levels of 1,000 WLM or more. In this series, 11 miners had total cumulative radiation exposures in excess of 1,000 WLM.

The mean length of time spent in the mines for this group was 11.0 years. Wagoner and his group[15] reported a tenfold increase in lung cancer among long-term uranium miners. Each of 13 miners in this study spent ten years or longer in the mines.

The induction-latent period in this study ranged from five to 30 years, with a mean of 15 years. Long induction-latent periods have previously been reported. Saccomanno and his group[17] reported an average induction-latent period of 15.9 years in their study of lung cancer among uranium miners. In our study, lung cancer did not appear sooner than five years from onset of exposure.

The predominant cancer appearing in this series was the small cell undifferentiated type, composing 62.5 percent. Small cell undifferentiated carcinomas occurred in excess in uranium miners,[17] which is in accord with our study.

Cigarette smoking has been accepted as a major etiologic factor in the causation of lung cancer.[18] Cigarette smoking also plays an important role in the excess of lung cancer among uranium miners.[4,9] However, in this study, of the 18 miners with lung cancer, 14 were nonsmokers; two miners were light to moderate smokers. Archer and his group[19] reported that lung cancer in cigarette-smoking uranium miners has a shorter induction-latent period than lung cancer in nonsmoking miners. We also observed a shorter induction-latent period in the two cigarette-smoking miners, of eight years each (mean induction-latent period for the group was 15 years). The foregoing data imply that the nonsmoking miners still have an increased risk of lung cancer, and their tumors take longer to develop.

A recent study has observed a high lung cancer risk among nonsmoking miners; that smoking seems to offer some protection against lung cancer.[9] The study suggests that there might be a decreased radiation dose to the epithelium in smokers because of a protective thick mucous sheath, since underground miners are prone to the development of bronchitis.

Information on smoking habits obtained from hospital records tends, at times, to be obscure. The smoking history data for this series appeared to be credible. Also, the Navajos are traditionally nonsmokers.

The early age at death in this group was noteworthy. The average age at death was 48.1 years. Six miners were aged 40 years or younger at death. One miner with lung cancer is still alive at age 52.

Conclusions

1. Features of the lung cancers observed among the 18 Navajo uranium miners are consistent with those observed by others among whites, which are largely attributed to radiation exposure.

2. The minimal use of cigarettes among this group of uranium miners is a strong argument that cigarette smoking is not a major factor in the lung cancers of uranium miners. Our data indicate that cigarettes act as a promoting agent, and that radiation is the major cancer initiating agent.

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John N. BEGAY, et al., Plaintiffs.

v.

UNITED STATES of America, Defendant.

Phillip ANDERSON, et al., Plaintiffs.

v.

UNITED STATES of America, Defendant.

Nos. Civ. 80-982 Pct. WPC. Civ. 81-1057 Pct. WPC.

United States District Court, D. Arizona.

July 10, 1984.

As Amended July 16, 1984.

Former Navajo uranium miners who worked both on and off Navajo reservation, and survivors of deceased Navajo uranium miners brought actions against the United States, asserting various negligence claims arising from decisions of the federal government in the 1940's through the 1960's with respect to the mines and safety of the miners. The District Court, Copple, Senior District Judge, held that it was without subject-matter jurisdiction to proceed in the cases, since the alleged acts and omissions of government officials were shielded from tort liability by the discretionary function exception to the Federal Tort Claims Act.

Dismissed.

1. United States ⇐=12(8)

Waiver of sovereign immunity cannot be implied; statute and regulations must be strictly construed with respect to the latter.

2. United States ⇐=78(12)

Federal government's decisions in 1940's through 1960's to leave uranium mine safety outside Indian reservations to states, its failure to establish and enforce rigid radiation safety standards in underground uranium mines, and its failure to warn miners of possible radiation damage were shielded from tort liability by discretionary function exception to the Federal Tort Claims Act, and district court lacked subject-matter jurisdiction to proceed in cases asserting negligence claims arising from such government acts. Atomic Energy Act of 1954, §§ 1 et seq., 62, 67, as amended, 42 U.S.C.A. §§ 2011 et seq., 2092, 2097; Federal Metal and Nonmetallic Mine Safety Act, § 2 et seq., 30 U.S.C.A. § 721 et seq.; Walsh-Healey Act, § 1 et seq., 41 U.S.C.A. § 35 et seq.; 28 U.S.C.A. §§ 1346(b), 2671 et seq., 2674, 2680(a); Public Health Service Act, § 215(b), 42 U.S.C.A. § 216(b).

Stewart L. Udall, William P. Mahoney, Jr., Gilbert T. Venable, Phoenix, Ariz., Albert Hale, Window Rock, Ariz., Thomas S. Udall, Santa Fe, N.M., for plaintiffs.

A. Melvin McDonald, U.S. Atty., James Loss, Asst. U.S. Atty., Phoenix, Ariz., Paul Figley, Trial Atty., Torts Branch, U.S. Dept. of Justice, I. Avrum Fingeret, Edward Jiran, Laura Rockwood, Trial Attys., U.S. Dept. of Energy, Washington, D.C., for defendants.

MEMORANDUM OPINION AND ORDER

COPPLE, Senior District Judge.

BACKGROUND

The controversy involved in these two consolidated cases can be said to have had its first stirrings almost five hundred years ago in two small isolated villages in Europe.

In 1982 an Interim Report of a Health Study of the Uranium Mines and Mills by the Federal Security Agency, Public Health Service, the Division of Occupational Health and the Colorado State Department of Public Health (Def.Ex. 118) summed up the "European Experience":

> In the mines of the Erz Mountains, on both the Bohemian and Saxon side, it has been known for centuries that the miners die in the prime of life with symp-

toms of damaged lungs and rapidly progressing ill health. These conditions, especially well known at the Schneeberg mines in Saxony, have been mentioned or described by many writers, including Agricola in 1500, Matthesius in 1559, and Pansa in 1814. It was not until 1879, however, that certain European investigators, through clinical and anatomical research, proved the affliction to be a malignant tumor of the lungs.

On the Bohemian side of the Erz Mountains in Czechoslavakia, about 30 kilometers south and east of Schneeberg, is Jachymov. This small mining town of about 8,000 inhabitants has been world famous as a source of radium from the beginning of the present century, but the history of the mines dates from the 1500's. Early in 1516, rich veins of silver were found in the Jachymov area. Exploitation was then begun but owing to the wasteful methods of mining at that time, the veins were almost exhausted by the end of the 16th century. Later, these mines were exploited for cobalt, nickel, bismuth, and arsenic. In the second half of the 19th century the exploitation began of uranium ore, found chiefly in the form of pitchblende. After Madam Curie's discovery of radium, the pitchblende in the Jachymov mines was processed for radium.

In Jachymov, as in Schneeberg, there has been a high mortality among the miners from pulmonary diseases, notably lung cancer. The similarity between the diseases developed by the miners in these two mining areas was not definitely established until about 1928. Environmental studies have shown that both mines have rather high concentrations of radon because of the presence of radioactive ores.

The causative agent for the lung cancers in these two mining areas has been controversial for a number of years. The etiological agent has been variously ascribed to be cobalt, nickel, or arsenic. Others have expressed the view that radon and its decay products are responsible for the cancer of the lungs. It is probable, however, that no single agent can be blamed for this high incidence but a number of combined effects of environmental factors which are difficult to evaluate.

Information available in the medical literature of this country indicates there was an attack rate of about 1 percent per year of lung carcinoma among the miners working in these mines. It is also reported that 50 to 70 percent of all the deaths of the workers in these mines were due to a primary cancer of the respiratory system. This information was the only material available which indicated the health hazards associated with uranium mining.... It must be pointed out, however, that this disease usually has developed only after an average exposure of seventeen years. Moreover, in any attempt to use these findings as a guide, cognizance must be taken of the fact that, in contrast to European practices, American operations are more intermittent. According to the Atomic Energy Commission, generally only one shift is employed, and the mines are not worked on a round-the-clock basis.

Also quoting from defendants' Exhibit 118 as to Radon, its Biological and Physical Properties:

> Uranium ores contain uranium plus all the other members of the radioactive family, of which uranium is the parent. Included in this list is radium, which is transformed into radon gas.
>
> Radon is the heaviest gas known, being about seven times as dense as air. It is absolutely inert chemically and will react with no other material. As it is a gas, it will diffuse from the rocks or be released by drilling and blasting operations and will become dispersed throughout the atmosphere of the mine. It is radioactive and has a half life of about four days, which means that in this period of time one-half of the radon will transmute into other radioactive elements.

The radiation hazard involved in the mining of uranium ores comes from the radioactive gas, radon, and two of its most important daughters, RaA and RaC'. All of these elements emit alpha particles which are very energetic and will damage body cells with which they interact.

As radon is a gas, it is breathed in along with the air in the mine and while in the lungs will continue to decay, emitting alpha particles and producing RaA, RaB, RaC, and RaC'. The daughters of radon will also decay in the lungs, likewise emitting alpha particles besides gamma and beta. Furthermore, some of the radon enters the blood stream. Potential hazard to the lung tissue arises mainly from the alphas from Rn, RaA, and RaC'.

Under usual mine conditions, large numbers of dust particles and water droplets are present in the atmosphere to which the solid decay products of radon will become attached. This dust will be inhaled and carried into the lungs where a portion of it will be retained and decay as outlined above, thus delivering additional radiation to the lungs. The amount of this dust-borne radioactivity that is present in mine atmospheres will depend on the ventilation, air turbulence, and probably other factors.

Case No. Civ. 80-982 Pct. WPC was filed in 1980 with ultimately 144 plaintiffs. In 1981 case No. Civ. 81-1067 Pct. WPC was filed with 61 plaintiffs. These cases were consolidated for all further proceedings. All plaintiffs are Navajo Indians residing on the reservation in Arizona. They are either Navajo miners who formerly worked in the underground uranium mines in Utah, Colorado, New Mexico and Arizona, both on and off the Navajo reservation, or survivors of such deceased Navajo uranium miners.

This trial involved eleven miners or their survivors, as a representative group, selected from Civ. 80-982, to-wit:

Zahe Gray
James Garnenez
Horace Ben
Dan T. Benally
Roy Bekis
Roy Benally
Lee C. Cory
Clarence Frank
Will Tuni
Kee Yazzie
Robert Yazzie

Plaintiffs allege jurisdiction pursuant to the Federal Tort Claims Act, 28 U.S.C. §§ 2671 *et seq.* The identical claims are based on injuries allegedly caused by excess exposure to ionizing radiation in the uranium mines from 1948 through 1961. Plaintiffs allege various legal theories in support of their complaints and the government asserts various defenses which will be discussed later in this opinion.

For easy reference and identification of abbreviations used hereinafter, a Glossary of Abbreviations is attached as Appendix A.

FINDINGS OF FACT

Because the facts and chronology of relevant acts and events are largely undisputed, the court has borrowed liberally from the government's very detailed and complete statements contained in its proposed findings of facts. Also see the court's tentative findings and conclusions as summarized at the end of the trial. (Tr. 2233–2248). The legal consequences flowing from those acts and events are very much in dispute.

Mining of uranium-vanadian bearing ores in the United States began at the turn of the century in the Uravan Mineral Belt portion of the Colorado Plateau in western Colorado and Eastern Utah. The ores were first mined for uranium for use as a ceramic coloring agent and for radium, which is associated with uranium. Most of the mines were closed in 1923 because of competition from foreign sources of higher grade radium. In the 1930's, mining was resumed, this time for vanadium. The relatively small domestic supply of uranium obtained for the nuclear weapons devel-

oped by the Manhattan Project was derived from vanadium mill tailings. Mining of uranium for AEC use started in the late 1940's and grew rapidly during the 1950's. For example, in 1950, about 650,000 pounds of uranium oxide were purchased and in 1959, over 30 million pounds were purchased. (Pl.Ex. 115, pp. 155–156) Contraction in the industry began when demand reduced in 1956. Many mines closed and the size of the industry steadily decreased. (Pl.Ex. 115, pp. 157–158)

There was a wide range in the size of individual uranium mines and in the types of mines in the various states. Wyoming had a large number of small mines mainly underground. New Mexico developed most of the large underground mines, but also the largest open pit mine. A comparatively few large mines produced most of the ore. (Pl.Ex. 115, p. 156)

Size of the work forces varied as widely as the size of the mines. A comparatively few large mines employed most of the underground labor. In the mid-1960's, New Mexico mines employed about one-half of all uranium miners, although they represented only 5 percent of the total number of uranium mines. Mines in Colorado and Utah employed less than 8 percent of the miners, although they represented about 50 percent of the total number of uranium mines at that time. (Pl.Ex. 115, p. 156) There were only 12 to 20 mines, small in size, located on the Navajo reservation, contrasted to more than 500 uranium mines overall. (Tr. 1884, 1886; Pl.Ex. 115, p. 232, 248)

Few uranium mines were large as compared with the size of other types of metal mines. Nevertheless, by 1966, approximately 2,900 miners were employed in the uranium mines. (Pl.Ex. 115, p. 156) Mining of uranium involved mining methods and equipment and hazards similar to those in other mines. (Pl.Ex. 115, p. 247) As with all types of mining, workforce turnover and accident rates were generally higher than in other industries. Miners, especially in the small mines, moved from mine to mine, and from mining to other occupations. Many were part-time miners (Pl.Ex. 115, p. 157)

In August, 1949, when the industry in Colorado had expanded substantially and was producing sizable quantities of uranium ore, officials of the Colorado Department of Health and the Colorado Bureau of Mines appointed an advisory board to assist in developing procedures to be used in conducting studies and surveys in the uranium mining and milling industry. Among the conclusions reached at the first meeting of the advisory group were that not enough was known of the potential health hazards from radiation in the uranium producing industry, and that a medical/environmental survey should be made by a physician from the U.S. Public Health Service (PHS). An initial survey of the mines was conducted to determine their radiation levels. Subsequent to this initial survey, a second meeting of the advisory group was convened with representatives of the large mining companies of Colorado. It was decided at this meeting that because of the absence of sufficient available information on the health hazards from radiation associated with the uranium producing industry, PHS should be formally requested to conduct a study of the uranium mines and mills to assess whether health hazards existed, and if so, to determine the nature and magnitude of such hazards, and to assist the states and mining companies in developing control procedures. This request was prepared and formally submitted to the Surgeon General of the United States on August 30, 1949. Shortly thereafter, PHS responded that it was willing to conduct the study requested. (Def.Ex. 482, pp. 1–2; Tr. 1894, 1925; Pl.Ex. 115, pp. 100, 171, 818; Def.Ex. 2906; Pl.Ex. 3; Pre-Trial Order, Stip. 81)

During initial negotiations for planning the health study, the PHS conducted a limited study of the problems in mines located on the Navajo reservation. The preliminary information indicated that the miners were exposed to very high external radiation, radon gas, and high silicate dust con-

taining an undetermined amount of radiation. (Pl.Ex. 3)

One purpose of the epidemiological study was to determine whether there was any reason to believe that the European experience in the Schneeberg and Joachimsthal mines would be repeated in the United States. Another purpose of the study was to attempt to control atmospheric conditions in mines. (Tr. 2029)

At the inception of the PHS study, there was not unanimity among the scientific community as to the causes of lung diseases of miners at the Joachimsthal and Schneeberg mines. In fact, respected members of the scientific community considered that other minerals such as arsenic and cobalt were involved in the cancers of the miners from Joachimsthal and Schneeberg. (Tr. 1038, 2073)

At the inception of the PHS study, it was decided by the study advisory committee that the study would consist of two phases: a medical investigation and an environmental investigation. With respect to the medical investigation, the original concept of the study was to examine all uranium millers and underground miners annually to obtain biologic, social and occupational data. Physicians would give each individual a general physical examination, a chest x-ray would be taken, and blood and urine analyses would be performed. This practice was continued in 1950, 1951 and 1953 when, for a variety of reasons, it was decided to shift to examinations on a triennial basis. The triennial examinations were continued until 1960. (Pl.Ex. 115, p. 101; Pl.Ex. 3; Pre-Trial Order, Stip. 1; Tr. 437; Pl.Ex. 3)

The PHS study of uranium mines was planned with two primary objectives. One was to determine the relationship between exposures to radioactivity and the biologic effect on the miners. A second objective was to develop engineering methods to minimize the exposures to radioactivity and make those methods available to the state mine regulators and to the mining industry. (Pl.Ex. 115, p. 100)

To assist in the design and execution of the study, PHS requested and received cooperation and assistance from the Atomic Energy Commission (AEC) Division of Biology and Medicine, the U.S. Department of Interior, Bureau of Mines (BOM), the Los Alamos Scientific Laboratory and the Atomic Energy Project of the University of Rochester. (Pl.Ex. 115, pp. 100–101)

With the advice of these agencies, the protocol for the study was designed, determining: who and what would be studied, for what period of time, and how the study would be conducted.

At all times relevant to this action, no federal agency had a right to enter uranium mines located on private property and regulated by the states. (Def.Ex. 1718, p. 17; Tr. 1882–1885, 1895, 1930, 1935, 1978–1979; Def.Ex. 32, p. 43; Pl.Ex. 115, p. 247) PHS had no authority to enter privately operated mines on the Navajo Indian reservation for the purpose of conducting environmental studies relating to silica dust and radiation levels, or to conduct physical examination of the miners. In order to proceed with the epidemiological study, it was necessary to obtain the consent and voluntary cooperation of all mine operators. To do this, it was decided by PHS under the Surgeon General that the individual miners would not be told of possible potential hazards from radiation in the mines for fear that many miners would quit and others would be difficult to secure because of fear of cancer. This would seriously interrupt badly needed production of uranium. While statistical information as to the environmental and medical data obtained could be released, no individual mine or mines would be publicly identified in connection with that data. Consequently, the voluntary consent of mine operators was secured to conduct the PHS study. (Tr. 113–117, 128, 2044–2046)

At all times relevant to this action PHS was a part of the U.S. Department of Health, Education and Welfare (HEW) under the direct administration of the Surgeon General of the United States, and has never had authority to regulate health and

safety conditions in mines. (Tr. 1927; Def.Ex. 2318, p. 4)

The uranium miners' study by PHS was a prospective epidemiological study in which a cohort of miners was established and followed for an indefinite period of time. (Tr. 435–436) The study was designed to begin simultaneously to obtain environmental measurements of concentrations of radon in uranium mines and to conduct physical examinations among uranium miners, to be repeated at intervals to determine whether or not there were changing health effects observed in the miners over time. (Tr. 2029) The purposes of the medical examinations were to see if there were any findings that could reflect exposure to radiation and to create the cohort. (Tr. 1042) One of the considerations of the physical examinations was to induce the miners to volunteer for examination so that background information could be obtained for the study. (Tr. 1043)

Under the PHS study protocol, the results of the examinations were to be sent to the miner's physician and to the miner himself. (Tr. 2061) The protocol did not provide for medical treatment or care for miners. On the contrary, the plan for the study provided that miners would be notified of abnormal findings in the test results and advised to see their treating physicians. From time to time, for a variety of reasons, the protocol for the study was altered. (Pl.Ex. 115, p. 101; Def.Ex. 180, pp. 9–10; Def.Ex. 6, p. 5; Tr. 106, 165–171, 1042, 1055)

The physical examinations were conducted at all uranium mining areas including the Navajo reservation, by medical and technical teams. (Tr. 448, 449, 450) If there were suspicious test results for a miner, the miner was referred to local medical facilities or to treating physicians for diagnostic studies and/or treatment. At no time did PHS attempt to undertake or to represent that it would undertake the health care of the members of the study group. (Tr. 1044–1048; Def.Ex. 183–187; Def.Ex. 6, p. 5; Def.Ex. 2291 and 2292)

All Indians with significant abnormalities of any kind were informed of the findings and when indicated were advised to seek medical care at one of the Indian Service hospitals. Reports on all significant abnormal findings were forwarded to the Indian hospital at Fort Defiance, either to Dr. Margolus or to Dr. Organick.

Physical examinations were conducted in conformity with the medical examination standards existing between 1950 and 1961. (Tr. 1043) The x-rays that were taken conformed to the standards in accepted medical practices existing in the 1950's. (Tr. 1043–1044)

The physicians conducting the medical examinations did not treat the miners examined for past medical conditions, for conditions observed during the course of the examination, and did not provide follow-up treatment to the persons examined for any conditions observed during the course of the examination. (Tr. 1044; See also FF 15) The PHS referred the persons examined to their private physicians or, in the case of Navajo miners, to the PHS Indian Hospital for follow-up treatment. (Tr. 1044)

During the course of the examination, the Navajo miners were told that the examination was part of a study of the health of uranium miners. (Tr. 451) Each miner was notified of any condition observed during the course of the physical examination. Where Navajo miners were involved, the results of the physical examinations also were sent to the Indian Health Service Hospital. (Tr. 508, 1044–1046)

During the course of the medical examinations, interpreters were used for non-English speaking Navajo miners. Interpreters were needed primarily for obtaining occupational and medical histories of the persons examined. (Tr. 1049–1050) Where a history was obtained of a non-English speaking Navajo, an interpreter was used. (Tr. 1050)

For the 1964, 1967 and 1980 physical examinations, the miners signed consent forms. By signing the consent forms, the miner requested that any significant abnor-

mal findings be reported to his personal physician. (Tr. 452–453, 507) There was no consent form used in connection with the 1950 examination. Because of the voluntary nature of the examination, however, the miner impliedly gave consent for such examination and for release of the information to his physician. (Tr. 2049) The examination and consent forms utilized as part of the epidemiological study were consistent with the standards for epidemiological studies in the 1950's to early 1960's. (Tr. 2038)

The primary reason for discontinuation of physical examinations in 1960 was the development of a new diagnostic process, sputum cytology. It was decided that the application of this diagnostic procedure to the uranium mining population would be more meaningful than physical examinations. The process of sputum cytology consists of a microscopic pathological examination of sputum cells which, to the expertly trained eye, will reveal early indications of the development in the respiratory system of deformed cells which are the precursor of cancer. Sputum samples have been collected from miners on an annual basis since 1960 and are still being collected today. (Pl.Ex. 115, p. 101; Tr. 1529)

In the design of an epidemiological study generally, there is a specific set of objectives set forth in a protocol. Here there was no objective and, indeed, it was not part of the protocol, to educate miners as to the hazards of uranium mining. (Tr. 2085–2086, 2078)

The physicians conducting the medical examinations had the responsibility for dealing only with the examination and the results of that examination. Therefore, it was neither necessary nor proper for these physicians to advise the miners voluntarily appearing for examinations of potential hazards in uranium mines. (Tr. 2042–2043)

During the course of the uranium miner study, employees of the United States were attempting to achieve lower concentrations of radon daughters in underground uranium mines through education of the mine operators. (Tr. 1056; See also FF 23)

There was no risk to the miner examined in the course of the physical examinations, and, on the contrary, there was a benefit to be derived by the individual miner. The minimal risk due to the chest x-ray was greatly exceeded by the benefit to the miner in determining if there were pulmonary lesions. There was further benefit to be derived by having a personal physician, or in the case of a Navajo, the PHS Indian Hospital, notified of any positive findings from the physical examinations. (Tr. 2042, 2043)

A physician is ethically bound to be truthful in what he tells a person being examined about the results of the examination. Accordingly, the PHS physicians examining the uranium miners reported to each miner any adverse indications found in the course of his examination and informed the miner that the results of the examination would be sent to his private physician or to the PHS Hospital on the Indian reservation. (Tr. 2051)

An epidemiological study deals with group statistics and the conclusions of such a study appropriately cannot be applied to specific participants of a group. (Tr. 2054–2055) The PHS study was designed to study persons already engaged in the mining industry. The government did not seek volunteers to work in the mines so that they could become part of the study group or cohort. (Tr. 1054, 1055)

The miners who were members of the study group were not recruited by the federal government to work in mines or to be placed in a particular mine atmosphere. (Tr. 2050, 2051) Employees of the United States neither caused the underground uranium miners to be exposed to any deleterious substance nor withheld treatment from any individual. (Tr. 1056–1057)

The PHS epidemiological study protocol and the conduct of the PHS physicians participating in the study and the limits on the information given to the miners studied were consistent with the medical ethical and legal standards of the 1940's and 1950's. It was not until the 1964 and 1965

period that federal guidelines were established for the conduct of federally-funded research projects. This followed discussions in the legal community, the medical community and congressional hearings after the Nuremberg trials of Nazi war criminals engaged in human experimentation in the German concentration camps. (Tr. 2075–2087) The PHS physicians here were not experimenting on human beings. They were gathering data to be used for the establishment of enforceable maximum standards of radiation exposure in uranium mines.

To collect mortality data on the study of the 3,415 miners with underground experience, it was necessary to maintain contact with the individuals. This was accomplished through an annual census of the uranium mining industry by newspaper obituaries and by mail questionnaires. Attempts were made to trace unaccounted for individuals through the U.S. Postal Department, Social Security Administration, employment offices, vital statistic records, credit bureaus, and the Veteran's Administration. A final means of ascertaining death and disability was through claims to the Bureau of Old-Age and Survivors Insurance. Through these follow-up efforts contact was maintained with 95% of the original study group. (Pl.Ex. 115, p. 101–102; Def.Ex. 182 and 2997)

The environmental investigation consisted of determining the levels of radon, radon daughters, and silica in the various mines. (Pl.Ex. 3) In the initial years of the environmental investigation in the mines, Colorado State employees conducted the surveys, which were funded by a grant from the National Cancer Institute of PHS. AEC supplied equipment and logistical support. (Tr. 1896, 1967) Although AEC could not allocate funds to state governments to assist in conducting the miners' study (Def.Ex. 32, p. 63), it could and did contribute personnel and equipment and the facilities of AEC to assist PHS and the states in collecting, measuring and analyzing data. (Tr. 1538–1539, 1896; Def.Ex. 2305, p. 4, para. 6–7)

AEC was especially active in providing assistance to the states and mine operators in ventilation techniques. As early as 1952, AEC began experimenting with mine ventilation techniques to reduce radon concentrations. (Tr. 1575, 1896; Pl.Ex. 150, p. 30)

Prior to 1951, all radiation measurements and studies of the biological effects of radon were based on the assumption that the significant alpha-particle energy was delivered to the lungs by the decay of radon in the respiratory tract. In 1951, it was recognized that the radiation decay products (daughter products) of radon contributed the greater portion of the radiation dose to the lung tissue. The inhalation of these particulates with their associated radioactivity results in a radiation dose to the lung tissue.

Animal experiments and calculations showed that under conditions similar to those found in mines, the radiation dose from radon gas alone was only 5% or less of the total dose delivered by the radon daughters. It was recognized that if the daughter products could be removed from the air inhaled by the miner, the radiation dose to the lung could be reduced by approximately 95%. (Pl.Ex. 115, p. 142)

Two possible controls of the problem were presented after 1951. First, if the level of radon and radon daughters in the mines could be kept at the lowest possible level, the radioactive exposure to the lungs would be minimized. Mechanical ventilation of the mines was found to be very effective in removing both the radon and daughters. Second, filtration of the air being breathed by the miner to remove the radon daughters was a possibility. However, since the science of protection by air filtration through the use of respirators was not well developed in 1951, the PHS study team determined that greater protection could be secured through adequate mechanical ventilation of mines. (Pl.Ex. 115, p. 142)

As an ancillary activity to its environmental investigation, in 1951, PHS began a series of training courses on the subject of

ventilation to control radon gas and radon daughters. The courses were for the benefit of mining company personnel and state mine regulators. PHS was assisted in this endeavor by BOM and ventilation experts from some of the major mining companies. (Pl.Ex. 115, p. 104; Tr. 166) PHS also conducted an "Occupational Health Program" for the education of mine operators and miners themselves. (Def.Ex. 2315, p. 2; Pl.Ex. 135) Between 1951 and 1955, staff members of PHS held conferences with officials of state mining and health agencies and the management of most of the uranium mining companies to explain the radiation health problems and to recommend control procedures. (Pl.Ex. 115, p. 104; Pl.Ex. 2; Pre-Trial Order, Stip. 37)

The new concept of the relationship between radon daughters in the atmosphere and dose to lung tissue also required the development of improved instrumentation as well as a new standard related to the alpha energy released by the radon daughters instead of radon gas. Although no federal standard existed and no safe level of concentrations had been established by competent authority, the PHS, based on certain evidence, calculated a tentative standard of 300 micro micro curies of total alpha emitting products per liter of air. This value is the equivalent of the term "one working level." (Pl.Ex. 115, p. 142)

AEC sponsored and conducted research for the development of more sensitive and accurate monitoring and measuring equipment to be used during mine inspection activities, human dosimeters which could be worn by miners underground revealing accurate cumulative doses of radiation, and lightweight respiratory devices to be worn by miners underground without inhibiting either their activity or vision so as not to expose them to harm from other non-radiation related mining accidents. (Tr. 1568, 1575–1577; Def.Ex. 2328, pp. 44–45)

After 1952, the PHS conducted no surveys of the environment in uranium mines located on the Navajo reservation. Sampling after that time was conducted by the BOM and subsequently the State of Arizona. (Tr. 115) BOM continued a program of surveying mines on Indian land from 1953–1958. Its findings and recommendations were reported to the U.S. Geological Survey (USGS) for enforcement action. (Pl.Ex. 247; Pl.Ex. 150, p. 30)

In May 1952, the "Interim Report" was published by the PHS to inform mining companies and state and other governmental agencies about the hazards and extent of the problem of radon daughters in underground uranium mines. This report contained recommendations for controlling the high levels of radon daughters in such mines. (Tr. 139–140; Pl.Ex. 3) The Interim Report was widely distributed. (Tr. 190; Def.Ex. 2320)

In 1953, the Joint Committee on Atomic Energy (JCAE) made official inquiries concerning the health and safety conditions in the uranium mines of the Colorado Plateau. (Tr. 1890; Def.Ex. 2309 and 2310)

Employees of the United States and of the various states participated in conducting surveys to determine the level of radon and radon daughters in various mines. State employees surveyed uranium mines for radon in Colorado beginning in 1950. After 1951, mines were surveyed for radon daughter products. In 1952, radon daughter samples were taken by employees of PHS in 157 mines. Through the efforts of Utah inspectors and PHS employees, every uranium mine in that state was surveyed in 1953 and 1954. In New Mexico, state employees had taken over the surveying tasks by 1954. In 1955–1960, PHS limited its participation in radon daughter surveys to assisting the state agencies. In 1955, Arizona began a program to survey every mine. By 1956, most of the large mining companies were surveying the mines which they operated and state employees surveyed the independent mines. In 1959–1960, in addition to all the continuing state programs, Utah conducted another survey of every mine, Colorado did the same and New Mexico instituted a continuous monitoring program. (Pl.Ex. 150, p. 30; Pl.Ex. 50, p. 30) Reports of the surveys were supplied to the mining companies in which

the levels of radon daughters were explained. (Tr. 168, 179–180, 213)

Instrumentation for the purpose of measuring radon daughters in underground uranium mines was available to mining companies in 1951, and some companies had such equipment in 1951 to enable them to make their own measurements. (Tr. 193–194) The PHS calibrated such measuring instruments for the mining companies to ensure their reliability. (Tr. 122)

On March 14, 1954, the PHS issued AECU Bulletin No. 2858 entitled "Control of Radon and its Daughters in Mines by Ventilation." (Pre-Trial Order, Stip. 40) In February 1955, PHS convened the "Seven State Conference on Health Hazards in Uranium Mining," at the request of Utah state mining officials. The conference featured consideration of radon hazards in underground mines and of control methods based on safe working levels advocated by PHS (300 picocuries/liter, or 1 WL). Representatives of seven uranium mining states, PHS, BOM, AEC, mine operators, mining equipment manufacturers, and independent scientific groups and institutions attended the conference. (Pl.Ex. 56, pp. 99–104; Tr. 1575)

BOM accepted the standard recommended by PHS at the Seven States Conference for the purpose of its mine inspections (Pl.Ex. 115, p. 247) and for instructional purposes in its safety education program for miners and mine operators. (Pl.Ex. 115, pp. 232, 248) Inasmuch as PHS had no mine regulatory authority, its informal radiation standard of 1 WL could only be a suggestion to state mine regulators and mine operators. It was incorporated into the mining codes of Colorado, New Mexico, and Utah. (Pl.Ex. 115, pp. 103–104; Def.Ex. 2900; Tr. 1901–1906) AEC adopted the 1 WL standard for enforcement in AEC-leased mines (Tr. 1907–11; Def.Ex. 1238 and 1239).

In 1956, the Research and Development Subcommittee of the Joint Committee on Atomic Energy began an inquiry into radiation hazards. Also in 1956, proposed legislation to authorize BOM to inspect metal and nonmetal mines was considered by the House Committee on Education and Labor at hearings on mine safety. During the course of those hearings, there was testimony relating to the potential health hazard from radiation in uranium mines. (Tr. 1881; See, Hearings before House Committee on Education and Labor, on Mine Safety (84th Cong.) 305 et seq., 488–489; Hearings before House Committee on Education and Labor, on H.R.4111 (85th Cong., 1st Sess.), 37–40, 61).

In 1957, PHS published a bulletin entitled "Control of Radon and Daughters in Uranium Mines and Calculations on Biologic Effects," PHS Publication No. 494. (Pl.Ex. 115, p. 104; Def.Ex. 3006) This bulletin was made available to all uranium mining companies, state health and mining agencies, appropriate federal agencies, the scientific community and others concerned. Publication No. 494 became a handbook for mine inspections, and, among other things, called attention to the potential health problems resulting from exposure to high concentrations of daughter products and summarized the evidence on which the suggested standard of 300 picocuries, or 1 WL, was based. (Def.Ex. 3006, pp. 3–10) It also contained the results of experiments to demonstrate the effectiveness of mechanical ventilation under actual mine conditions and a method for the collection and measurement of the concentration of radon daughters. In addition, the bulletin presented recommendations for controls other than ventilation. (Def.Ex. 3006, pp. 45–74; Tr. 198–200)

In 1957, the excess lung cancers in uranium miners in the United States were not statistically significant. (Tr. 1067, 1068) In 1958, for the first time, epidemiological data resulting from the PHS study seemed to indicate a statistical excess above the number of expected deaths among miners from lung cancer. Although the statistical data were far from conclusive, it was the first apparent evidence linking lung cancer and exposure to high concentrations of radon daughters. (Tr. 1961, 1068–1069, 1970; Def.Ex. 330)

In March 1959, the General Manager of AEC on behalf of the Commissioners suggested to the Surgeon General that an interdepartmental conference be convened to consider what federal action, if any, could be taken to address the uranium mining problem. (Def.Ex. 2991) The Secretary of HEW, with the cooperation of the Chairman of the AEC and the Secretaries of Interior and Labor, appointed an Interagency Committee charged with the responsibility of examining the uranium miners' problem and recommending federal action. The committee met on September 28, 1959, and rendered its report to the Secretary of HEW on November 12, 1959. (Def.Ex. 2319; Tr. 1919 *et seq.*)[1]

The interagency Committee analyzed existing federal responsibilities and found that the U.S. Department of Interior could inspect mines and enforce health and safety provisions only with respect to mines located on public or Indian lands but not with respect to mines located on private lands. mines were excluded from AEC jurisdiction by the Atomic Energy Act; PHS of the U.S. Department of HEW was limited to research, investigation, and the provision of technical assistance to the states; and, although it had some responsibility under the Public Contracts Act for health and safety in mines owned by milling companies under contract with the United States, the U.S. Department of Labor could not provide the technical assistance to control mine atmospheres. (Tr. 1920–1930; Def.Ex. 2319, pp. 4–5)

The Interagency Committee recommended to the Secretary of HEW "that every effort should be made to impress upon the States the seriousness of this problem and the need to assume their rightful responsibilities" over regulation of mine health and safety conditions. To achieve this goal, the committee recommended that a conference be convened by the Secretary with participation by the U.S. Department of HEW, Interior, Labor and AEC and the governors of the uranium mining states. The Committee specifically recommended against new federal legislation which would preempt the state's traditional police power over the regulation of mine safety. (Tr. 1920–1930; Def.Ex. 2319, p. 5)

The Secretary of HEW adopted the Committee's recommendations and in concert with the Secretary of Interior and the Chairman of the AEC, convened a Conference of Governors of the uranium mining states in December 1960. The attendees included the Secretary of HEW, interested federal agencies, the Governors, state agencies and management representatives of mining companies. (Def.Ex. 2317, 2318, 2319, 2296; Tr. 1920–1924 and 1930–1931) At the Conference, the Secretary of HEW, on behalf of all interested federal agencies, extended a program of assistance to the states encouraging progress toward control of radon daughters. (Def.Ex. 2992)

Notwithstanding the desire of the various uranium mining states to have the technical and financial assistance of the federal agencies in endeavoring to solve the radon daughter problem, it was always clear that the state governments regarded the regulation of mine health and safety as state business. Preemptive federal legislation providing for federal regulation of mine health and safety was something that neither the states nor the federal government desired. (Def.Ex. 32, pp. 42, 43, 57, 67; Tr. 1930)

Prior to 1960, state officials had great difficulty in trying to persuade mine operators and miners that a large volume of ventilation, in some cases at considerable cost, was needed to correct the intangible hazard of radiation. There was no positive evidence at that time that radon gas or its daughter products, which could not be seen, smelled, or tasted, were or could be harmful. (Def.Ex. 32, p. 57; Def.Ex. 6, p. 7; Pl.Ex. 115, p. 318)

The states responded to the Governor's Conference and the offer of federal assistance with an increasingly strong position in

1. Transcript of trial does not refer to the Report of the Interagency Committee with a separate exhibit number. The report above is Defendant's Exhibit 2319.

the regulation of mine safety. (Def.Ex. 2292; Tr. 1932–1935; Pl.Ex. 113, p. 143) Colorado state mining authorities identified hazardous conditions and acted with authority in requiring correction by mine operators beginning in 1960. (Pl.Ex. 113, p. 318; Tr. 1933–1934; Def.Ex. 2292) New Mexico established a standard of 1WL as suggested by PHS and an enforcement program was undertaken to bring mines within the state into compliance with the new regulatory limitations. (Def.Ex. 32, p. 38; Pl.Ex. 113, p. 323; Tr. 1932)

In 1959, subsequent to announcement by PHS of an apparent statistical increase in the incidence of lung cancer in uranium miners, AEC requested BOM to conduct a quarterly inspection of all AEC-leased mines located on land withdrawn by the AEC from the public domain and leased to independent operators. Thus, all AEC-leased mines were routinely inspected for radon concentrations beginning in 1959. Enforcement of control measures was a priority—some mines were closed—and the Chairman, Commissioners and JCAE were kept fully informed of the progress. AEC had concluded that it could enforce health and safety measures in leased mines pursuant to the leasing provisions of the Atomic Energy Act. (42 U.S.C. § 2097) Moreover, AEC required the formal amendment of all such mine leases to contain explicit enforcement language and procedures. (Tr. 1938–1946; Def.Ex. 732; 1498, pp. 29–31; 2283; 2289; 2298; 2300–2304; 2292, p. 5; Pl.Ex. 115, p. 242)

Also in 1959, the President, by executive order, established the Federal Radiation Council (FRC) as a panel of advisors to the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all federal agencies in the formulation of radiation standards and in establishment and execution of programs of cooperation with the states. Soon thereafter, the Congress ratified the President's action, making FRC a creature of statute (P.L. 86-373). The members of the Council were initially the Secretaries of HEW, Labor, Commerce, Defense, Agriculture, and the Chairman of AEC. Later, the Secretary of Interior was added. The President's Special Assistant for Science and Technology was included from the outset as an official consultant to the Council and the Secretary of HEW was designated Chairman. (Tr. 1319–1321)

The earliest agenda of FRC included consideration of radiation hazards to uranium miners and the establishment of a radiation standard for underground mines. (Tr. 1322) In 1960, FRC proposed to the President and obtained his approval of recommendations for the guidance of federal agencies in the conduct of their radiation protection activities applicable to manmade sources of radiation such as nuclear reactors, isotopes and x-rays. These recommendations did not include a standard for uranium mines. In 1959, the President directed that HEW intensify its radiological health efforts and have primary responsibility within the executive branch for the collection, analysis and interpretation of data on environmental radiation levels. (Def.Ex. 629; Tr. 1322)

From approximately 1960–1967, during the FRC's extensive study of the problem of exposure to radon daughters, including a re-evaluation of data contained in the PHS study of uranium miners, the FRC Chairman was critical of the pace of progress by state mine regulators in requiring control of radon concentrations through ventilation. In communications with the Chairman of the AEC, the FRC Chairman indicated his decision to coerce the Governors of the uranium mining states into action by issuing a threat at the 1961 Western Governor's Conference to propose legislation to the Congress for federal authority to preempt state regulatory authority over uranium mines. (Def.Ex. 2285; 2306, pp. 7–8)

In 1959, an additional series of hearings was conducted by JCAE, investigating "Employee Radiation Hazards and Workmen's Compensation." In the Committee summary of the hearings pertinent to radiation hazards in underground uranium mines, testimony revealed opposing views. On the one hand, federal legislation was

suggested to usurp regulation of mine health and safety from the states. On the other hand, federal assistance was suggested to guide the states in carrying out their mine regulatory responsibilities. The Committee staff concluded that more studies were needed to determine a safe low threshold of ionizing radiation, and furthermore, that present data—including PHS data—were inconclusive. The problem was recognized as one which could be resolved only with the application of judgment. (Tr. 1915–1918; Pl.Ex. 41, pp. 1, 3, 6)

However, even in 1960, the only available means of control was to regulate average atmospheric radiation to a point where exposure time to the sample concentration would be as near to the standard for a year's exposure as it was possible to estimate. There was no practical instrument (dosimeter) developed at that time that would actually measure each man's accumulated dose of alpha radiation within a factor of plus or minus 50%. Thus, even with mine enforcement programs in place, precise determination as to individual dose and related hazard was not possible. (Pl.Ex. 115, p. 318; Tr. 1578, 1582; Def.Ex. 2329, p. 46) Notwithstanding these technical difficulties, Colorado's program for the control of radon concentrations in underground mines was enforced and where necessary, mines were closed. (Pl.Ex. 115, p. 323)

In the early 1960's, AEC established a Labor-Management Advisory Committee with members representing the federal government, corporate management, and labor unions. Among the committee's projects was to draft workmen's compensation legislation for proposal by the Commissioners to the Congress, to assure that uranium miners suffering from lung cancer would be reasonably compensated for their injuries. (Tr. 1957; Pl.Ex. 115, p. 179 et seq.)

In 1960, BOM developed a new field method for estimating daily exposures of underground uranium miners to airborne radon daughter products. This method became a useful tool, not only for the purposes of inspection by state mining officials, but also for the control efforts of mining companies. (Pl.Ex. 115, p. 247)

In 1961, the Industrial Commission of Utah requested and received cooperation from BOM in making a joint inspection of every operating underground uranium mine in Utah. The purpose of this joint venture was to train state inspectors and to establish a foundation of data on existing uranium mines in the state for guidance of state officials in the future. Fifty-three privately owned mines were inspected under this joint program. (Pl.Ex. 115, p. 247)

In 1961, the Department of Interior was authorized by PL 87-300 to conduct a two-year study into health and safety hazards in metal and non-metallic mines. The Department's report to the Congress in 1963 was the basis of congressional consideration of legislative proposal which ended with enactment of the Metal and Nonmetallic Mine Safety Act of 1966. This Act authorized the Department of Interior to establish uniform standards, including radiation standards for underground mines, and to inspect all mines. (Tr. 1935–1936; Def.Ex. 2289; Tr. 1956) To assist in the study, the Secretary of Interior requested and received the cooperation of the Chairman of the AEC. (Tr. 1936; Def.Ex. 2289) From the outset of its uranium procurement activities, AEC proceeded on the principle that regulation of mine safety was traditionally a responsibility of the individual states and it was especially sensitive to federal impingement of state authority. (Def.Ex. 32, pp. 29, 63; 2990, p. 2; Tr. 1893, 1899, 1929, 1978, 1979).

The AEC did not have regulatory authority over mines located on private land and regulated by the states. However, AEC did have regulatory authority over processing mills, but even that authority was limited to source, byproduct and special nuclear material which were defined by Section 62 of the Atomic Energy Act of 1946, and only to such material "after removal from its place of deposit in nature." Since radium and radon gas (including radon daughter products) as they occurred in the mines

were not covered by the definitions of source, byproduct or special nuclear material, they were not subject to AEC's regulatory authority. Thus, uranium mining was not within AEC's statutory authority. (Pl.Ex. 115, p. 159; Tr. 1536, 1540, 1596, 1882-1883, 1389, 1926, 1929, 1930, 1935)

On a number of occasions, the General Counsel of AEC formally advised the Commissioners that AEC possessed no statutory authority to regulate health and safety in uranium mines located on private land. Furthermore, he advised against any attempt by AEC to regulate such mines. (Tr. 1537-1543; Def.Ex. 2312, 2313)

At all times pertinent to this litigation, the Department of Labor was of the opinion that the Public Contracts Act had clear application to uranium mines which were directly controlled by the uranium mills under procurement contract with the AEC. Independent mines which were not controlled by either the milling or the mining companies that operated the mills were not believed to be covered by the provisions of the Public Contracts Act. (Pl.Ex. 115, p. 47)

AEC contracted only for the purchase of uranium concentrates from the mills, not for the purchase of ore from the mines. (Pl.Ex. 115, p. 157) The AEC contracts for procurement from the mills contained broadly phrased "health and safety" stipulations in accordance with the Public Contracts Act requirements. (Pl.Ex. 115, p. 47) The Secretary of Labor did not promulgate safety and health standards for uranium mining until 1967, and no safety and health inspections of uranium mines were made by Department of Labor inspectors. (Pl.Ex. 115, p. 47)

The reason, as stated by the Secretary of Labor, for not taking action in this area prior to 1967 was that "the general and prevailing view was that other agencies, Federal and state, could more appropriately exercise here both the standard-setting and the inspection functions . . . . The record reflects continuing attention by a variety of state and federal agencies—including the Department of Labor—to both the standards and the inspection problems in connection with uranium mining." (Pl.Ex. 115, p. 47; Def.Ex. 32, p. 76; Tr. 1537-1542, 1926-1927, 1931; Def.Ex. 2312 and 2314) Moreover, it was evident that "instrumentation (was) not (then) commercially available for accurately measuring the concentration of radon daughter products in the ambient mine atmosphere on a continuous or near continuous basis, and that there (was) not . . . available any form of personal dosimeter capable of measuring the dose of radon daughter products actually received by a miner." (Pl.Ex. 115, p. 95; Tr. 1567-1572)

In deposition testimony recorded in 1982, ex-Secretary of Labor Willard Wirtz stated that it was not by inadvertence that the Secretary of Labor did not act under the provisions of the Public Contracts Act with respect to uranium mining until 1967. (Wirtz Deposition, pp. 24 *et seq.*, 26-27) Correspondence from the Secretary of Labor to JCAE demonstrates that the Department of Labor was considering promulgation of separate regulations for radiation exposure in uranium mines as early as 1962 but was awaiting the formulation of a standard by FRC. (Def.Ex. 651)

In 1967, Secretary Wirtz published a proposed standard for radon daughter concentrations in underground mines of 0.3WL/liter. Also in 1967, Secretary Wirtz proposed workmen's compensation regulation in an effort to provide for the uranium miners who had not yet but might in the future contract lung cancer. (Def.Ex. 672; Tr. 1937)

On July 27, 1967, the President approved FRC's proposal for a uniform federal radiation standard for underground uranium mines. (Tr. 1535-1536; Def.Ex. 414; 507) Notwithstanding the absence of a federal radiation standard for underground uranium mines prior to 1967, there is a record of considerable improvement in the average concentrations to which miners were exposed from 1957-1968.

During the 1967 hearings conducted by JCAE, an exchange between the Chairman of the committee and a Commissioner of

AEC demonstrated the long cumulative process involved in understanding and resolving the uranium mine problem (Tr. 961; Pl.Ex. 113, pp. 175–176):

Representative HOLIFIELD. I recognize that my next question is going to bring up the ever-present conflict of jurisdiction between State and Federal Government, but laying that factor aside for the moment, and considering the AEC's expertise in the radiation field, do you think that maybe we could have handled this in a sounder way if the AEC had been charged with the responsibility of controlling radiation from uranium and radon mines from the beginning?

Mr. RAMEY. Mr. Chairman, I think hindsight is always a little easier in looking at things that way. It is true that AEC has a great deal of expertise in the radiation field. On the other hand, the Public Health Service, of course, has been the expert on the epidemiological studies. This has been recognized from the start. They have been doing a good job on this.

Mr. Holaday has been following this from the year 1, so we do not think that their role has been hurt at all in this sort of thing.

Representative HOLIFIELD. In other words, there has been expertise in the field applied to the problem over these years by the Public Health Service?

MR. RAMEY. Yes, sir, in that context.

I think, also, on the mining side as such, the AEC, again, does not have all of the expertise certainly on mining and mine ventilation, and so on. That is why we cooperated with the Bureau of Mines and, of course, with the State people in regard to leased mines. We did consider and do consider ourselves to have some expertise on the radiation aspects of it.

Representative HOLIFIELD. At least in the interpretation of radiation levels.

Mr. RAMEY. Yes. And we do in other areas, of course, at the mill level and with respect to reactors, with respect to radioisotopes, we do have a rather comprehensive regulatory program.

Representative HOLIFIELD. Can you say with confidence that the AEC has discharged its responsibility in the mine and laboratory in regard to safety from radiation?

Mr. RAMEY. Yes, and in terms of research we have been working on various aspects of research and development relating to dosimeters, relating to respirators, and this type of thing.

We recognize, I think, that perhaps we could have done some more. A number of us think that in hindsight we probably could have had a little more leadership on whether or not we had the authority to move these things a little faster.

Representative HOLIFIELD. *But we were accumulating knowledge in this field. I mean, the AEC, as well as the committee, has been accumulating knowledge in this field, and some of the latest knowledge that has come to us has been in the form of conclusions that have been long in the making.*

Mr. RAMEY. Yes, sir. The Joint Committee hearings in 1959, in which Mr. Holaday testified, brought up the uranium miner problem.

At that time, though, there had only been, as I recall, four deaths. *It was not clear from the NEW Public Health Service epidemiological studies exactly how that trend was going to go. It began to become clearer, I think, in 1961 and 1962, as I recall, that the trend was going to follow the same way that it had done in Europe in the Silesian mines and so on.*

It was in the period in the mid-1960's where we could have probably moved a little faster. As you know, there were various other problems and factors involved that were being given priority attention, namely, fallout and related criteria. (Emphasis supplied)

Even as late as the 1967 JCAE hearings there was still disagreement among the witnesses and committee members as to the proper maximum radiation exposure

levels that should be set for the underground uranium mines as well as concern that Secretary Wirtz' levels were impractical and too high. (Def.Ex. 585; Pl.Ex. 115)

The U.S. BOM inspected uranium mines on the Navajo reservation pursuant to the Secretary of Interior's Order No. 1940, dated April 3, 1944. (Tr. 1092) The USGS had enforcement authority over uranium mines on the Navajo reservation and the BOM had inspection authority. (Def.Ex. 2288) Copies of the USGS Inspection Reports were sent to the Navajo Mining Engineer, an employee of the Navajo tribe. (Def.Ex. 2929) But the Department of Interior (BOM and USGS) had no legally established radiation exposure standards for underground uranium mines to enforce until they were established in 1967.

The State of Arizona also inspected mines on the Navajo reservation. State inspector, Anthony Bennett, has conducted inspections for dust and ventilation for the State of Arizona in uranium mines on the Navajo reservation since 1951. (Tr. 1379–1380)

The State of Arizona sent inspection reports to Duncan Holaday of the PHS, to the Navajo Tribal Council, to the Deputy Mine Inspector of the State of Arizona and to the superintendent of the actual mines. (Tr. 1382, 1385)

On two occasions, the Arizona Mine Inspector determined that there were hazardous dust conditions in uranium mines on the Navajo reservation. Although the Arizona inspector had no authority to issue closure orders, he notified a representative of the USGS who did have such enforcement authority. The USGS representative made an immediate inspection of the mines and issued closure orders pursuant to his authority. (Tr. 1390–1393, 1396–1396)

The Tribal Council is the legislative body that enacts the laws of the Navajo nation. (Tr. 564) Under the laws of the Navajo nation, the Navajo Mining Engineer, as employee of the tribe, had the authority to enter and inspect all mines on the Navajo reservation, as well as the authority to close mines located on the Navajo reservation to remedy any condition or practice which is a menace to life, limb, or health. The authority of the Navajo Mining Engineer to close mines existed whether or not there was a violation of any state or federal mining regulation. (Def.Ex. 2985; Tr. 378–379)

The BOM and the USGS notified the Navajo Mining Engineer of radon daughter readings in uranium mines on the Navajo reservation and the levels of free silica existing in such mines. Representatives of the BOM and USGS further indicated means of correcting any hazardous conditions that they found in such mines. (Tr. 582–588; Def.Ex. 2926, 2929, 2966)

Representatives of the United States, including employees of the PHS and BOM, met at various times with representatives of the Navajo tribe to discuss the radon concentrations in underground uranium mines on the Navajo reservation and to enlist the aid of the Navajo Mining Engineer to assist in making surveys therein. (Tr. 580–581; Def.Ex. 2568)

The weight of the evidence, including medical testimony, statistical data and historical events, leaves no doubt that there is a direct relationship between the high levels of radiation exposure suffered by the underground uranium miners and their excessive incidence of respiratory tract and lung cancer. The respiratory tract and lung cancers involved in this case were caused by excess exposure to radon daughters in the underground uranium mines. The one case of bladder cancer was not so caused.

ADDITIONAL FINDINGS OF FACT

1. At the time of commencement of the U.S. Public Health Service study none of the western uranium mining states had trained personnel, equipment or other resources to establish, monitor and enforce maximum radiation exposure levels in their underground uranium mines. This was also true of the Navajo Mining Engineer. The State of Colorado moved rapidly to implement the developing recommendations

of the PHS and ultimately achieved a very effective control program. Utah and New Mexico were much less successful. The Arizona Mine Inspector had no legislative authority during the decade of the 1950's to establish or enforce maximum exposure levels of radiation. Other than making measurements of radiation levels for PHS in the late 1950's, he did nothing.

2. The Atomic Energy Commission had developed very effective radiation level controls in the mines owned by the mills with which it had procurement contracts. This information and the techniques used were available for all state and federal agencies. The Public Health Service, during all of the period of the 1950's, was disseminating information about radiation control by mine ventilation to the states, the Navajo Mining Engineer, and the mine operators. For whatever reason, other than Colorado, little or nothing was done by the states or the Navajo Mining Engineer to force the mine operators to improve ventilation in their mines. Although the PHS demonstrated that adequate mine ventilation would be relatively inexpensive, the mine operators successfully resisted efforts to substantially reduce radiation levels by improved ventilation techniques.

3. All during the decade of the 1950's the radiation exposures in some mines were found to be more than one thousand times the maximum working level recommended by the Public Health Service. These levels were higher than those in the European mines and even higher than the radiation doses received as a result of the atomic bomb explosions in Japan during World War II.

4. After the initial mine survey by PHS, federal government officials and decision makers in both the executive and legislative branches were aware of the continued excessively high radiation levels in the underground uranium mines as reported by PHS.

LEGAL DISCUSSION AND CONCLUSIONS OF LAW

The plaintiffs generally complain that various governmental agencies were actionably negligent in leaving uranium mine safety outside the Indian reservation to the state; were negligent in failing to enforce rigid radiation safety levels in the reservation mines; that the PHS study was a good samaritan undertaking negligently performed in that miners were not warned of possible radiation damage; and that all involved federal agencies were negligent in failing themselves to establish and enforce rigid radiation safety standards in the underground uranium mines in the 1940's, 1950's and early 1960's.

The government's main defenses are the discretionary function exception to the Federal Tort Claims Act (FTCA); the misrepresentation exception to the FTCA; that the PHS study was not a good samaritan undertaking; that the claims are time-barred; and lack of causation.

[1] It is Hornbook law that the United States can be sued only to the extent that it has waived its immunity. *United States v. Orleans*, 425 U.S. 807, 813–814, 96 S.Ct. 1971, 1975–76, 48 L.Ed.2d 390 (1976). Waiver of sovereign immunity "cannot be implied." *United States v. Testan*, 424 U.S. 392, 399, 96 S.Ct. 948, 953–54, 47 L.Ed.2d 114 (1976); *United States v. King*, 395 U.S. 1, 4, 89 S.Ct. 1501, 1503, 23 L.Ed.2d 52 (1969). The statutes and regulations must be strictly construed. *Childers v. United States*, 442 F.2d 1299, 1303 (5th Cir.), *cert. den.*, 404 U.S. 857, 92 S.Ct. 104, 30 L.Ed.2d 99 (1971); *Hurley v. United States*, 624 F.2d 93, 95 (10th Cir.1980).

In *United States v. Orleans*, *supra*, the Supreme Court unanimously reaffirmed the principle that "the Federal Tort Claims Act is a limited waiver of sovereign immunity" and that "[s]ince the United States can be sued only to the extent that it has waived its immunity, due regard must be given to the [Act's] exceptions." 425 U.S. at 813–814, 96 S.Ct. at 1975–76.

The FTCA, 28 U.S.C. § 2674, provides in pertinent part:

> The United States shall be liable, respecting the provisions of this title relat-

...ng to tort claims, in the same manner and to the same extent as a private individual under like circumstances ....

The "discretionary function exception" is found in 28 U.S.C. § 2680(a):

> The provisions of this chapter and section 1346(b) of this title shall not apply to—
>
> (a) Any claim based upon an act or omission of the Government, exercising due care, in the execution of a statute or regulation, whether or not such statute or regulation be valid, or based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty on the part of a federal agency or an employee of the Government, whether or not the discretion involved be abused.

The leading case on the discretionary function exception is *Dalehite v. United States*, 346 U.S. 15, 73 S.Ct. 956, 97 L.Ed. 1427 (1953). *Dalehite* involved claims arising from the cataclysmic explosion of shiploads of government fertilizer at Texas City, Texas. Plaintiffs claimed that numerous acts of the United States were negligent: the cabinet-level decision to institute the fertilizer export program; the failure to experiment with the fertilizer to determine the possibility of explosion; the drafting of the basic plan of manufacture; and the failure properly to police the storage and loading of the fertilizer. The Supreme Court held that the plaintiffs' claims against the United States were encompassed within the discretionary function exception. The Court stated:

> It is unnecessary to define, apart from this case, precisely where discretion ends. It is enough to hold, as we do, that the "discretionary function or duty" that cannot form a basis for suit under the Tort Claims Act includes more than the initiation of programs and activities. It also includes determinations made by executives or administrators in establishing plans, specifications or schedules of operations. Where there is room for policy judgment and decision there is discretion.

Id. at 35–36, 73 S.Ct. at 968.

Until very recently, it was thought that *Dalehite* had been narrowed by *Indian Towing Co., Inc. v. United States*, 350 U.S. 61, 76 S.Ct. 122, 100 L.Ed. 48 (1955), and *Rayonier, Inc. v. United States*, 352 U.S. 315, 77 S.Ct. 374, 1 L.Ed.2d 354 (1957). *See* Judge Jenkins' thorough discussion in *Allen v. United States*, 527 F.Supp. 476, 479–86 (D.Utah 1981). Indeed, plaintiffs in the cases *sub judice* rely heavily on *Indian Towing*.

In *Indian Towing*, plaintiff sought damages for cargo aboard a vessel that had run aground, allegedly owing to the failure of the Coast Guard to inspect, maintain, and repair a light in a lighthouse. In *Rayonier*, the Court "revisited an issue considered briefly in *Dalehite*: whether the United States may be held liable for the alleged negligence of its employees in fighting a fire." *United States v. S.A. Empresa De Viacao Aerea Rio Grandense (Varig Airlines)*, — U.S. —, —, n. 10, 104 S.Ct. 2755, 2765 n. 10, 81 L.Ed.2d 660 (1984). In *Varig Airlines*, the Supreme Court distinguished *Indian Towing* and *Rayonier*. The Court explained that in *Indian Towing*

> the Government *conceded* that the discretionary function was not implicated, ... arguing instead that the [Federal Tort Claims] Act contained an implied exception from liability for "uniquely governmental functions." The Court rejected the Government's assertion, reasoning that it would "push the courts into the 'non-governmental'—'governmental' quagmire that has long plagued the law of municipal corporations."

Id., — U.S. at —, 104 S.Ct. at 2764 [citations omitted] [emphasis in original]. The Court also noted that in *Rayonier*, the Court had held that the liability of the United States under the FTCA is not restricted to that of a municipal corporation or other corporate body. This holding, while obviously overruling one element of the judgment in *Dalehite*, did not disturb the more fundamental aspects of *Dalehite*,

including its construction of § 2680(a). *Id.* at n. 10. Finally, the Court noted that, as in *Dalehite*,

> it is unnecessary—and indeed impossible to define with precision every contour of the discretionary function exception.

Id., — U.S. at —, 104 S.Ct. at 2765.

The Court found it possible, however, to set forth several factors that are useful in determining when the acts of a government employee are protected from liability by § 2680(a).

> First, it is the nature of the conduct, rather than the status of the actor, that governs whether the discretionary function exception applies in a given case. As the Court pointed out in *Dalehite*, the exception covers
>
> "[n]ot only agencies of government ... but all employees exercising discretion." Thus, the basic inquiry concerning the application of the discretionary function exception is whether the challenged acts of a Government employee—whatever his or her rank—are of the nature and quality that Congress intended to shield from tort liability.
>
> Second, whatever else the discretionary function exception may include, it plainly was intended to encompass the discretionary acts of the Government acting in its role as a regulator of the conduct of private individuals.

Id. The Court applied these factors, and held that the discretionary function exception operated to bar suit for claims arising out of the allegedly negligent certification of aircraft by the Federal Aviation Administration. *Id.*, — U.S. at —, 104 S.Ct. at 2768.

[2] Applying these factors to the cases *sub judice*,[2] this court concludes that the acts of the government officials in the instant cases are shielded from tort liability by the discretionary function exception. The "nature of the conduct" in the instant cases is of the type that Congress plainly intended to shield from tort liability.

Although the Supreme Court made it plain in *Varig Airlines* that it is the nature of the conduct, and not the status of the actor that is the critical factor, it also is true that "[t]he higher the governmental rank involved in making any decision of this type, the more likely it is that political, social, military and economic factors were weighed." *Nevin v. United States*, 696 F.2d 1229, 1231 (9th Cir.1983), *cert. den.*, — U.S. —, 104 S.Ct. 70, 78 L.Ed.2d 84. As reflected in the findings above, the decisions, the acts and omissions complained of, were made at the highest levels of the executive and legislative branches.

State and Federal Responsibility for Mine Safety Enforcement

Historically mine safety enforcement had been totally the responsibility of the individual states. The passage of the Coal Mine Safety Act in 1952 marked the first federal encroachment in this area. As the name implies, it was strictly limited to coal mines. It was not until 1966, partly as a result of the uranium mining experience, that the Metal and Nonmetallic Mine Safety Act was passed placing ultimate responsibility on the federal government for safety enforcement in all mines in the United States.

Pursuant to that historical political policy the executive and legislative branches early in the period of uranium mining on the Colorado plateau, and at the very highest levels, made conscious policy decisions to leave mine safety enforcement in the hands of the states. The federal government undertook only responsibility for research in this area, distribution of research data to the states and the making of recommendations to the states.

The evidence in this case as to meetings of high level government officials, conferences between uranium mining state governors and representatives of federal agencies, and transcripts and summaries of congressional committee hearings in the 1950's and early 1960's and even as late as the Joint Committee on Atomic Energy hearings in 1967 (Pl.Ex. 115), demonstrates the

2. *Varig Airlines* was decided subsequent to briefing and argument in the instant cases.

repeated iteration and concern for this history of state-federal responsibilities and the consciousness at all levels of this policy (*e.g.*, Pl.Ex. 115, p. 175). *Cf. Varig Airlines, supra*, — U.S. at —, 104 S.Ct. at 2768 ("When an agency determines the extent to which it will supervise the safety procedures of private individuals, it is exercising discretionary regulatory authority of the most basic k "). It necessarily follows that when high government officials determine the extent to which they will leave mine safety enforcement to the states, they are exercising discretionary authority "of the most basic kind."

Indian Mines

The federal government since 1944, through the Department of Interior and its Bureau of Mines and United States Geological Survey unit, retained mine safety enforcement only on Indian reservation mines. On the Navajo reservation mines in Arizona, the state mine inspector had authority to inspect for dust control but not for radiation exposure levels. For enforcement he had to rely on the USGS. After training by PHS, the Arizona Mine Dust Inspector did monitor radiation levels in Indian mines and provided data to PHS.

The U.S. Bureau of Mines had authority to check radiation levels in Indian uranium mines. However until 1967, no legally enforceable maximum radiation levels had been established. During all of the 1950's there were constant discussions at high levels marked by disputes as to what maximum levels of radon daughter concentrations should be established. There were no adequate or reliable dosimeters or other equipment developed until the mid and late 1960's to constantly monitor and record exposures of individual miners or in the mine environment itself. There were no adequate individual respirators for miners. The AEC had ongoing research and development projects in all these areas.

At the highest management levels, the BOM and USGS, as did the Department of Labor (Tr. 1952-54), made conscious decisions to take no direct actions in this area until legally enforceable and physically practical standards had been adopted by the federal government. *See, e.g., Barton v. United States*, 609 F.2d 977 (10th Cir. 1979); *Coastwise Packet Co., Inc. v. United States*, 398 F.2d 77, 79 (1st Cir.), *cert. den.* 393 U.S. 937, 89 S.Ct. 300, 21 L.Ed.2d [illegible] (1968); *Dalehite v. United States*, supra, 346 U.S. at 34, 73 S.Ct. at 967; *see also Relf v. United States*, 433 F.Supp. 423 (D.D.C.1977), *aff'd* 593 F.2d 1371 (D.C.Cir. 1979).

> As stated in *Barton, supra*, at page 979:
>
> Concisely stated, the rule is that if a government official in performing his statutory duties must act without reliance upon a fixed or readily ascertainable standard, the decision he makes is discretionary and within the exception of the Tort Claims Act. Conversely, if there is a standard by which his action is measured, it is not within the exception. The statute provides that if the act of the official is discretionary it is not actionable even though the discretion is abused.

Until 1967 there were no such fixed standards. Prior to 1967, the PHS had recommended standards which were widely disseminated. The PHS urged the states to establish and enforce those standards. The PHS also urged mine operators on and off the Indian reservation to use mine ventilation techniques to try to achieve those recommended levels. Even in 1967, after Secretary Wirtz of the Department of Labor established standards, there were still high level fears that those regulations were unworkable. (Pl.Ex. 115; Def.Ex. 585)

The decisions regarding setting radiation standards required the agencies to balance "the objectives sought to be obtained against [the] practical consideration" that there was continuing dispute as to what levels of radon daughter concentrations should be adopted. *Cf. Varig Airlines, supra*, — U.S. at —, 104 S.Ct. at 2768. "Judicial intervention in such decisionmaking through private tort suits would require the courts to 'second-guess' the political, social, and economic judgments of an

agency exercising its regulatory function. It was precisely this sort of judicial intervention in policymaking that the discretionary function exception was designed to prevent." *Id.*

The Surgeon General, in agreeing that PHS would conduct the epidemiological survey and in establishing the protocol for the study, including the determination not to warn the uranium miners of possible radiation damage, made a policy and planning decision that is immune from court review under the discretionary function provision of the FTCA. He also was acting pursuant to 42 U.S.C. § 216(b), under the authority of which, with the approval of the Secretary of HEW, 42 C.F.R. § 1.103 was duly promulgated and in force from 1951 through 1978.

This regulation, which governed the disclosure of information obtained and conclusions reached for PHS surveys, research projects and investigation, provided in relevant part:

§ 1.103 *Nonclinical information; disclosure.* (a) Information in the records or possession of the Service obtained by the Service under an assurance of confidentiality which the Surgeon General or his authorized representative determines to be necessary for the purpose of any research, survey, investigation, or collection of statistical data *may be disclosed only with the consent of the person, association, or agency to which such assurance was given*, or whenever the Surgeon General specifically determines disclosure to be necessary (1) to prevent an epidemic or other grave danger to the public health or (2) to oppose any legal action related to the activities of the Service and brought against the United States or any of its officers or employees.

* * * * * *

(c) The following types of information in the records or possession of the Service are confidential and, subject to the provisions of paragraphs (a) and (b) of this section, shall be disclosed only as necessary for the performance of the functions of the Service, or as follows:

* * * * * *

(2) *Information and data obtained* and tentative and final conclusions reached *in the course of* or in connection with the conduct of *research projects, surveys and investigations may be disclosed at such times and to such extent as the Surgeon General or his designee may determine to be in the public interest.* (Emphasis supplied)

The decision to *not do* something is just as much a policy decision as one to do something. 28 U.S.C. § 2860(a), second clause; *Barlieb v. Turner & Newall, Ltd.*, Civil No. 78-1027, slip opinion at 10-11, (E.D.Pa. Nov. 28, 1980) (PHS decision not to disseminate information about asbestos or to warn the plaintiffs of the dangers inherent in working near asbestos was a discretionary function and the complaint was dismissed as to PHS); *Relf v. United States, supra.*

Underlying all of the decisions of federal agencies complained of by plaintiffs were concerns as to balancing the risk of radiation-induced injury and the benefits derived from the practice causing exposure to the miner. *Cf. Varig Airlines, supra.* — U.S. at ——, 104 S.Ct. at 2768 (balancing "objectives ... against practical considerations"). "An implicit part of such a balance is the necessity for considering the relation between the difficulties involved in reducing the radiation exposure by a given amount and the risk that might be associated with that amount of exposure." (Def.Ex. 2329)

The government, in making its decision in this area, was faced with the immediate need of a constant, uninterrupted and reliable flow of great quantities of uranium ore from the mines to the mills for urgent national security purposes and as an energy source in the future for the growing peacetime nuclear energy industry. Also

the decision makers had to be concerned that there was adequate data available to justify the standards to be set and that labor and management would have the tools to know when they were in violation (Tr. 1563–1572). Even in 1967 there was testimony before the JCAE that such tools were unavailable (Def.Ex. 115; Tr. 1565–1572).

At this point a hypothetical situation used by Judge Jenkins in *Allen v. United States*, No. C 79–0515–J (D.Utah 1984), to illustrate the extent of the discretionary function exception to the FTCA may be helpful in understanding the decision herein:

> Suppose a high level decision maker says, "International pressures make open-air atomic testing highly necessary. Time is of the essence. We cannot tell our own people. We just need to do it and do it as fast as we can. We know as a result of such testing some people are going to get hurt. We can't tell them they are going to get hurt. We can't even warn them what to do to minimize or prevent the hurt. In order to preserve our way of life some people unknown to them and unknown to us are going to give their all for the good of all."
>
> Policy decision? Yes. Tort Claims Act exception.
>
> Assuming appropriate power in the decision maker—a court, this court, would lack power to do anything at all about such a policy decision. Under that hypothetical, Congress, as a matter of conscience and not as a matter of legal duty would, it seems to me, recognize the equities and make redress as best it could.

(Slip opinion Civil at pp. 155–6). To the same effect, *see Nevin v. United States*, *supra*.

In *Nevin*, relatives of the deceased brought an FTCA claim alleging that decedent died as a result of the government's negligence in selecting a particular strain of bacterium for use in a secret, simulated biological warfare attack on City of San Francisco in 1950. The court held that the choice of the particular strain of bacterium used was a discretionary function and the government was immune from suit under FTCA.

The cases before this court are distinguishable from *Allen*, *supra*, a recent District Court decision which found for the plaintiffs in a nuclear bomb testing fallout case. There the decision to hold the test and where and when to hold it were discretionary functions and FTCA immune. However, as part of the implementing instructions for field personnel conducting the tests, very specific directions were given as to protection of residents of possible fall-out areas, including broad dissemination of warnings, education, safety precautions to be taken by persons in the fall-out area, etc. The field personnel, contrary to specific directions, did not warn; they reassured people that there would be no danger and failed in every respect to carry out their very detailed instructions as to protection of possible fall-out victims. Because of this negligence in carrying out a protected policy decision, the government was held liable for damages proximately caused by the fall-out.

In the cases *sub judice* the policy decisions, and especially the PHS study protocol, were carried out at the operational level in strict compliance with those exempt decisions. It therefore follows that the acts of the government employees in carrying out the policy decisions are protected by the discretionary function exception. *See Varig Airlines*, *supra*, — U.S. at —, 104 S.Ct. at 2762.

The court concludes that all the actions of various governmental agencies complained of by plaintiffs were the result of conscious policy decisions made at high government levels based on considerations of political and national security feasibility factors. All such decisions, including the PHS epidemiological study, were carried out as directed. Therefore this court lacks

subject matter jurisdiction to proceed in these cases. 28 U.S.C. § 2680(a); *DaleAite, supra*; *Nevin, supra*, 696 F.2d at 1231. Because the discretionary function exception is dispositive, there is no need to discuss the other legal theories of plaintiffs or defendant.

This tragedy of the nuclear age, however, cries for redress. Such relief should be addressed by the Congress as it was in the case of the Texas City explosion following the decision of the Supreme Court in *DaleAite, supra*; 69 Stat. 707; *see Laird v. Nelms*, 406 U.S. 797, 802-803, 92 S.Ct. 1899, 32 L.Ed.2d 499, *reh'g denied*, 409 U.S. 902, 93 S.Ct. 95, 34 L.Ed.2d 165 (1972); and as the Congress is currently considering in the Vietnam veterans Agent Orange cases.

IT IS ORDERED:

The complaints and actions of the selected plaintiffs which were tried in this severed trial are dismissed for lack of subject matter jurisdiction. The Clerk will enter judgment accordingly.

APPENDIX A

GLOSSARY OF ABBREVIATIONS

AEC	Atomic Energy Commission
BOM	United States Bureau of Mines, United States Department of the Interior
FRC	Federal Radiation Council
FTCA	Federal Tort Claims Act
HEW	United States Department of Health, Education and Welfare (now United States Department of Health and Human Services)
WL	"Working level." A measure of individual radiation exposure.
JCAE	Joint Committee on Atomic Energy
PHS	Public Health Service, Office of the Surgeon General, United States Department of Health, Education and Welfare (now United States Department of Health and Human Services)
USGS	United States Geological Survey, United States Department of the Interior

Arlene **KESSLER**, Richard Arena, and Margeritha Cameron, individually and on behalf of all others similarly situated, Plaintiffs,

v.

Barbara **BLUM**, individually and in her capacity as Commissioner of the New York State Department of Social Services; Russell Schwartz, individually and in his capacity as Deputy Commissioner for the Medical Assistance Division of New York State Department of Social Services; Robert Crane, individually and in his capacity as Director of the Office of Health Systems Management of the New York State Department of Health; James A. Krauskopf, individually and in his capacity as Commissioner of the New York City Department of Social Services, defendants.

No. 82 Civ. 4578(RWS).

United States District Court, S.D. New York.

July 10, 1984.

Certain medicaid recipients in New York State brought class action for declaratory and injunctive relief against state and city officials charged with administering prior approval program. The District Court, Sweet, J., held that: (1) medicaid recipients whose injuries would have been alleviated if requested relief had been granted had standing to bring the action, while those whose injuries would not have been alleviated lacked standing; (2) state administrators were not required to permit recipients to file direct requests for prior approval; (3) state administrators were not required to give recipients notice of approval of prior approval requests; (4) 21-day time limit would be imposed upon state administrators for initial determinations on requests for prior approval; (5) by requiring prior approval for any services provided in a situation which recipient's provider considered to be an emergency, state ad-

completed since the Environmental Impact Statement was approved in 1979 have not found any greater danger from direct-current lines than was known to exist before 1979. Moreover, no matter how much Henderson has grown since 1979, there are now no more than ten houses within the impact area of the transmission line. Because no new federal activity is proposed and the new material is not likely to affect the result reached in the old study, a new environmental impact statement is not necessary. *See* 40 C.F.R. § 1502.9(c)(1)(ii); *Warm Springs Dam Task Force v. Gribble*, 621 F.2d 1017, 1024–25 (9th Cir.1980).

Affirmed.

John N. BEGAY and his wife, Mable Lee Begay; Kee Atcitty; Bob B. Begay and his wife, Mae Begay, et al., Plaintiffs/Appellants,

v.

UNITED STATES of America, Defendant/Appellee.

Phillip ANDERSON, Marry John Badonie, Hoskie R. Barton, Clyde Begay, Harvey Lee Begay and Herbert N. Begay, et al., Plaintiffs/Appellants,

v.

UNITED STATES of America, Defendant/Appellee.

No. 84-2462.

United States Court of Appeals, Ninth Circuit.

Argued and Submitted May 16, 1985.

Aug. 13, 1985.

Navajo Indian miners exposed to radiation in uranium mines or survivors of deceased Navajo uranium miners brought action against the United States under the Federal Tort Claims Act alleging that they contracted lung cancer and other diseases from radiation exposure because of failure of various federal and state agencies to warn them of dangers involved in the mining. The United States District Court for the District of Arizona, William P. Copple, J., 591 F.Supp. 991, dismissed for lack of jurisdiction, and appeal was taken. The Court of Appeals, J. Blaine Anderson, Circuit Judge, held that: (1) discretionary function exception applies to nonregulatory acts, and (2) decision of Public Health Service not to warn plaintiffs of radiation dangers they were exposed to was clearly within ambit of the exception.

Affirmed.

1. Federal Courts ⇐776

If question requires appellate court to consider legal concepts in the mix of fact and law and to exercise judgment about values that animate legal principles, then concerns of judicial administration will favor appellate court, and question should be classified as one of law and reviewed de novo.

2. United States ⇐78(12)

Application of discretionary function exception of the Federal Tort Claims Act [28 U.S.C.A. § 2680(a)] is not relegated to strictly regulatory actions of agencies involved; rather, exception applies when agency makes decision that is grounded in social, economic and political policy. 28 U.S.C.A. § 1346.

3. United States ⇐78(12)

Decision of Public Health Service not to warn Navajo miners of radiation dangers they were exposed to while working in uranium mines was within ambit of discretionary function exception of the Federal Tort Claims Act [28 U.S.C.A. § 2680(a)], and therefore district court lacked jurisdiction in suit arising out of failure to warn. 28 U.S.C.A. § 1346.

Stewart L. Udall, Phoenix, Ariz., for plaintiffs/appellants.

Mark H. Gallant, Atty., Dept. of Justice, I. Avrum Fingeret, Trial Atty., U.S. Dept. of Energy, Washington, D.C., for defendant/appellee.

Appeal from the United States District Court for the District of Arizona.

Before ANDERSON and CANBY, Circuit Judges, and IDEMAN*, District Judge.

J. BLAINE ANDERSON, Circuit Judge:

I. OVERVIEW

The plaintiffs in this case are Navajo Indians residing on the reservation in Arizona. They are either Navajo miners who used to work in uranium mines or survivors of deceased Navajo uranium miners. The underground uranium mines involved in this case are located in Utah, Colorado, New Mexico, and Arizona, both on and off the Navajo Indian Reservation. More specifically, eleven plaintiffs were selected as a representative group for trial purposes out of more than 200 plaintiffs. The plaintiffs sought jurisdiction in the district court pursuant to the Federal Tort Claims Act (FTCA), 28 U.S.C. §§ 2671, *et seq.*

The plaintiffs allege that they contracted lung cancer and other diseases from radiation exposure because of the failure by the various federal and state agencies to warn them of the dangers involved in uranium mining. The plaintiffs additionally assert that the failure to warn the miners of the dangers of uranium mining unnecessarily exposed the miners to risks that could have been prevented. Plaintiffs also assert that this exposure resulted in the eventual death of some of the miners. The district court, after extensive discovery and a trial, dismissed the case for lack of jurisdiction based on the "discretionary function" exception of the FTCA. 28 U.S.C. § 2680(a)[1]. We affirm.

II. FACTS

The district court, in its opinion, *Begay v. United States*, 591 F.Supp. 991 (D.Ariz. 1984), sets forth a very thorough and comprehensive explanation of the factual background in this case. The agencies involved in this case are the Atomic Energy Commission (AEC), the U.S. Public Health Service (PHS), the AEC Division of Biology and Medicine, the Department of Interior's Bureau of Mines (BOM), the Los Alamos Scientific Laboratory, the Atomic Energy Project at the University of Rochester, the U.S. Department of Health and Welfare (HEW), the U.S. Surgeon General's Office, the U.S. Department of Labor, the U.S. Geological Survey (USGS), the Arizona Mine Inspector, and the Navajo Mining Engineer. Because the district court did such a thorough job in stating the facts in this controversy, we list only those facts that we find salient to resolving the issue before us.

Mining of ores bearing uranium-vanadium compositions was first started in the United States during the early 1900's. Most of these mines were located in what is called the Uravan Mineral Belt portion of the Colorado Plateau in western Colorado and eastern Utah. At first, mining of uranium ore was minimal and did not start to rapidly expand until the 1950's. This rapid increase in uranium mining was a result of the AEC's need for uranium in nuclear weapons production. Most uranium mines were smaller in size than other metal mines, but by 1966, approximately 2,900 miners were employed in uranium mines.

In August of 1949, the state of Colorado requested the help of the U.S. Public

* The Honorable James M. Ideman, United States District Judge, Central District of California, sitting by designation.

1. 2. Under 28 U.S.C. § 2680(a) [28 U.S.C.A. § 2680(a)], the United States may not be held liable under the Act for:

"Any claim based upon an act or omission of an employee of the Government, exercising due care, in the execution of a statute or regulation, whether or not such statute or regulation be valid, or based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty on the part of a federal agency or an employee of the Government, whether or not the discretion involved be abused."

Health Service to conduct a medical/environmental survey on the health hazards associated with uranium mining. The PHS survey was an epidemiological study which had two objectives: To determine the relationship between exposures to radioactivity and the biologic effect on miners, and to develop engineering methods to minimize the exposures to radioactivity and make those methods available to the state mine regulators and to the mining industry. The PHS received assistance on the project from the AEC Division of Biology and Medicine, the Department of Interior's Bureau of Mines, the Los Alamos Scientific Laboratory, and the Atomic Energy Project at the University of Rochester.

During the study, the PHS, as a part of HEW, was under the direct administration of the U.S. Surgeon General's Office. At no time did the PHS have the authority to regulate the safety conditions in the uranium mines. Likewise, the AEC had no authority under the Atomic Energy Act to regulate or enforce health and safety standards in mines. However, AEC did have the capability to influence the extent of safety equipment used in privately operated mines on government land leased from the AEC. This influence was exerted by rewriting the lease agreements between AEC and the owners of the private mines. By including certain requirements for safety equipment to be used in the mines as terms in the lease, AEC was able to indirectly regulate health and safety standards in the mines. The district court found that some of the other agencies did have, or perceived to have, some type of regulatory authority over the safe operation of the mines.

The Department of Labor did not conduct any inspections of the mines in question even though it was under the impression that it had some authorization to regulate mine safety pursuant to the Public Contracts Act. The district court found that Labor abstained from taking any action because of the prevailing view that other agencies, state or federal, could better set standards and enforce them.

The Department of Interior had authority to regulate mines located on Indian and public lands, but not private lands. The authority to inspect the mines, under the auspices of Interior, was given to the BOM and to the USGS in 1944. With regard to those powers, the district court found that the BOM and USGS did not have any clear federal standards by which to conduct their inspections. As a result, BOM and USGS sent copies of their reports of mine inspections to Arizona and to the Navajo Mining Engineer.

The Navajo Mining Engineer had the independent power to enter, inspect and close any mine on Navajo property. The Arizona Mine Inspector could inspect the mines, but could not order their closure.

With the scope of each agency's authority and power in mind, we look to the role of the PHS and their medical study. For purposes of the medical study the PHS established a cohort of miners, all volunteers, to whom they gave annual, then triennial, physical examinations. If test results from these physicals were abnormal, the miner was referred to local medical facilities for further treatment or study. In the case of the Navajo miners, referrals were sent to the PHS Indian Hospital. The PHS study team did not represent that it would provide health care to the members of the cohort.

When physical examinations were performed on Navajo miners who could not speak English, interpreters were provided. During the course of the physicals the miners were told that the examination was part of a study to determine the health of uranium miners. The district court stated that because an epidemiological study deals with group statistics, conclusions from the study cannot appropriately be applied to specific participants of a group. The district court also found that the PHS physicians conducting the examinations dealt only with that examination and its results, and that the conduct of the PHS doctors participating in the study and the limits of the information given to the miners studied was consistent with the medical ethical

and legal standards of the 1940's and 1950's.

In 1951, the environmental side of the PHS survey determined that radiation decay products (daughter products) of radon contributed the greater portion of the radiation dose to the lung tissue. In 1959, for the first time, the results from the PHS study indicated a statistical increase above the number of expected deaths from lung cancer among miners. Although not conclusive, it was the first apparent evidence linking lung cancer and exposure to high concentrations of radon daughters. As a result, it was suggested to the Surgeon General that an interdepartmental conference be convened to determine what action, if any, the federal government was going to take in response to this statistical increase of lung cancer deaths in uranium miners.

The Interagency Committee recommended to the Secretary of HEW "that every effort should be made to impress upon the states the seriousness of this problem and the need to assume their rightful responsibilities" over regulation of mine health and safety conditions.

In 1960, a Governors' conference was called of the uranium mining states and the federal government offered its assistance in correcting the perceived health problems associated with uranium mining. Federal legislation that would preempt state laws and regulation concerning mining safety was something that neither the states nor the federal government wanted. Historically, the state governments had felt the regulation of mine health and safety was a matter of state business. At the same time, however, federal assistance, both financial and technical, was desired to help solve the radon daughter problem.

Colorado and New Mexico did begin to regulate mine operations in the early 1960's based on the PHS recommendations as to the radiation exposure limits. However, not until 1967 was a uniform federal radiation standard for underground uranium mining established and implemented.

III. ANALYSIS

The gist of the plaintiffs' complaint falls into two general categories. First, that various federal agencies were negligent in failing to establish and enforce radiation safety standards in underground uranium mines when the dangers were first discovered. Second, that the PHS medical study done on the uranium miners within the cohort was a "good samaritan" undertaking, nonetheless done negligently, because the miners were not warned of the possible dangers of radiation exposure to their bodies.

The government's defense is the discretionary function exception of the Federal Tort Claims Act, 28 U.S.C. § 2680(a).

[1] On review, we are guided by two principles for determination of this case. First, "[f]indings of fact [of the district court] shall not be set aside unless clearly erroneous." Fed.R.Civ.P. 52(a). Second, "[i]f, ... the question requires ... [the appellate court] to consider legal concepts in the mix of fact and law and to exercise judgment about the values that animate legal principles, then the concerns of judicial administration will favor the appellate court, and the question should be classified as one of law and reviewed de novo." *United States v. McConney*, 728 F.2d 1195, 1202 (9th Cir.) (en banc), cert. denied, — U.S. —, 105 S.Ct. 101, 83 L.Ed.2d 45 (1984).

Resolution of the issues in this case is dependent on our construction and application of *Dalehite v. United States*, 346 U.S. 15, 73 S.Ct. 956, 97 L.Ed. 1427 (1953) and *United States v. S.A. Empresa De Viacao Aerea Rio Grandense (Varig Airlines)*, 467 U.S. —, 104 S.Ct. 2755, 81 L.Ed.2d 660 (1984). This is also our first opportunity to apply *Varig* to a case not involving strictly "regulatory" action of an agency.

2. In the past, we have used the planning level/operational level dichotomy when analyzing the application of the discretionary function exception. *See Alves v. United States*, 696 F.2d 1229 (9th Cir.1983), cert. denied, — U.S. —, 104 S.Ct. 70, 78 L.Ed.2d 84 (1983); *Olsen v.*

IV. APPLICATION OF VARIG

The underlying policy of the FTCA has been one of diminishing the immunity from suit of the federal government while at the same time spreading the economic loss suffered by the individual plaintiff. *See generally Indian Towing v. United States*, 350 U.S. 61, 68, 76 S.Ct. 122, 126, 100 L.Ed. 48 (1955); *Payton v. United States*, 636 F.2d 132, 144 (5th Cir.1981); *Downs v. United States*, 522 F.2d 990, 998 (6th Cir. 1975); *Smith v. United States*, 375 F.2d 243, 248 (5th Cir.1967). The federal courts have achieved the "spreading of the loss of the plaintiff," but not without great difficulty in determining when the discretionary function exception should or should not apply. *See* 35 Am.Jur.2d *Federal Tort Claims Act* §§ 15–36 (1967 & Supp.1984).

Dalehite described the discretionary function as "more than the initiation of programs and activities. It also includes determinations made by executives or administrators in establishing plans, specifications or schedules of operations. Where there is room for policy judgment and decision there is discretion. *It necessarily follows that acts of subordinates in carrying out the operations of government in accordance with official directions cannot be actionable.*" *Dalehite*, 346 U.S. 33, 36, 73 S.Ct. 956, 968, 97 L.Ed. 1427 (citations omitted) (emphasis added). Coinciding with the immunity afforded to subordinates when carrying out the decisions of higher officials, the discretion of those officials themselves is protected. "It is the discretion of the executive or the administrator to act according to one's judgment of the best course, a concept of substantial historical ancestry in American law." *Id.* at 34, 73 S.Ct. at 967 (citation omitted) (emphasis added).

The decision of the Supreme Court in *Varig*, rejecting an argument that *Dalehite* no longer represented "a valid interpretation of the discretionary function exception," identified several factors the courts should consider when deciding whether the discretionary function exception should apply. *Varig*, ___ U.S. at ___, 104 S.Ct. at 2764, 81 L.Ed.2d at 673.

Varig involved suits against the United States alleging that the Civil Aeronautics Agency had been negligent in inspecting certain aircraft modifications. It was alleged that faulty modifications to the airplanes resulted in, or contributed to, the ultimate crash of each plane and loss of lives. Reversing this circuit's decision which allowed the plaintiffs to recover under the "good samaritan" rule of California, the Supreme Court held that the discretionary function exception of the FTCA barred the suit. *Varig*, at ___, ___, 104 S.Ct. at 2759, 2769, 81 L.Ed.2d at 667, 679.

[2] The plaintiffs in this case argue that *Varig* should only apply to regulatory decisions made by federal agencies. We disagree. *Varig* dealt with facts involving regulatory activities, but it is clear from the legislative history quoted and relied upon by *Varig* that limiting its application to regulatory decisions is inappropriate.

"It is neither desirable nor intended that the constitutionality of legislation, the legality of regulations, or the propriety of a discretionary administrative act should be tested through the medium of a damage suit for tort. *The same holds true of other administrative action not of a regulatory nature, such as the ex-*

Varma, 729 F.2d 841 (2d Cir.), cert. denied, ___ U.S. ___, 105 S.Ct. 293, 83 L.Ed.2d 230 (1984); *Griswold v. United States*, 730 F.2d 177 (3d Cir. 1984). Courts and commentators have noted that the use of the planning level/operational level distinction is either too simplistic or too complicated and inaccurate. *See generally Smith v. United States*, 375 F.2d 243 (5th Cir.), cert. denied, 389 U.S. 841, 88 S.Ct. 70, 19 L.Ed.2d 105 (1967); Note, *The Discretionary Function Exception to the Federal Tort Claims Act*, 1983 Utah L.Rev. 117 (1983); Note, *Federal Tort Claims Act: The Development and Application of the Discretionary Function Exception*, 13 Cum. L.Rev. 333 (1982/1983).

In recognition of the problems that surround the application of the discretionary function exception, and in light of the Supreme Court's recent decision in *Varig*, we believe that the proper approach to determining when the exception applies is for the court to look to the nature of the conduct in question.

penditure of Federal funds, the execution of a Federal project and the like." *Varig*, at ——, 104 S.Ct. at 2763, 81 L.Ed.2d at 672 (citation omitted) (emphasis added). *Dalehite* also makes it clear that "it was not contemplated that the Government should be subject to liability arising from acts of a governmental nature or function." 346 U.S. at 28, 73 S.Ct. at 964 (footnote omitted). Thus, the congressional intent of the discretionary function exception shows that its application is not relegated to strictly regulatory actions of the agencies involved. Non-regulatory acts, like the ones in question here, fall within the framework of the exception as Congress has intended.

In *Varig*, the Supreme Court determined that courts should give due regard to the following factors when deciding if the discretionary function exception should apply. First,

> it is the nature of the conduct, rather than the status of the actor, that governs whether the discretionary function exception applies in a given case.... Thus, the basic inquiry concerning the application of the discretionary function exception is whether the challenged acts of a Government employee—whatever his or her rank—are of the nature and quality that Congress intended to shield from tort liability.

Varig, — U.S. at ——, 104 S.Ct. at 2765, 81 L.Ed.2d at 674. This consideration applies to "all employees exercising discretion." *Dalehite*, 346 U.S. at 33, 73 S.Ct. at 966.

Second, "Congress wished to prevent judicial 'second-guessing' of legislative and administrative decisions grounded in social, economic, and political policy through the medium of an action in tort." Therefore, if judicial review would encroach upon this type of balancing done by an agency, then the exception would apply. *Varig*, — U.S. at ——, ——, 104 S.Ct. at 2764, 2765, 81 L.Ed.2d at 673, 674. The question whether review is appropriate at this stage involves certain considerations of the separation of powers. *Allen v. United States*, 527 F.Supp. 476, 483, 485 (D.Utah 1981) ("One must understand that the words 'discretionary function' as used in the Tort Claims Act are really the correlative, the other side of the coin, of the exercise of executive power."). *See generally* Note, *The Discretionary Function Exception: Is it a Bar to Federal Jurisdiction?*, 1983 Utah L.Rev. 177. *See also Allen*, supra.

As *Varig* points out, the exception applies when the agency makes a decision that is grounded in social, economic, and political policy. This is the very reason that the exception was passed. Congress wanted to prevent the courts from deciding in tort actions the policy and regulatory types of decisions that have been delegated to the agencies.

A. Nature of the Conduct

[3] Some of the agencies involved in this case did have some type of authority to regulate activity in the mines. These agencies, the Department of Labor (under the Public Contracts Act), the Department of Interior (regulations on Indian or public lands), the BOM, the USGS (both working under Interior), the Arizona Mine Inspector, and the Navajo Mine Inspector, chose to either implement safety regulations in the uranium mines, or not to. These decisions are clearly within the ambit of the Supreme Court's decision in *Varig* covering regulatory agencies. "When an agency determines the extent to which it will supervise the safety procedures of private individuals, it is exercising discretionary regulatory authority of the most basic kind." *Varig*, — U.S. at ——, 104 S.Ct. at 2765, 81 L.Ed.2d at 674.

Our inquiry proceeds to the decision of the Public Health Service, acting under the Surgeon General, not to disclose to the miners the possible health hazards involved in working in the uranium mines. At the time, in order to get the cooperation of the owners of the various mines and to retain the members of the cohort for study, PHS decided not to warn the miners of the possible radiation hazards associated with uranium mining. *Begay*, 581 F.Supp. at 1562. The decision not to warn the Navajo miners

was apparently made by Holaday, who at the time of the investigation was the Chief of PHS's Western Area Field Station in charge of research in 15 states. Holaday was also in charge of the environmental stage of the study of uranium miners involved here.

We find that the decision reached by Holaday, not to disclose the possible dangers of uranium mining to the miners, was based on his judgment of what the best course of action was under the existing circumstances. *See Dalehite*, 346 U.S. at 34, 73 S.Ct. at 967 ("The discretion protected by the section is not that of the judge—a power to decide within the limits of positive rules of law subject to judicial review. It is the discretion of the executive or the administrator to act according to one's judgment of the best course....") (citations omitted).

B. *Social, Economic, or Political Policy Decision*

We also consider whether or not judicial review of the agency decision encroaches on the traditional discretionary powers of the executive branch. In this regard, the Office of the Surgeon General was acting "with the approval of the Secretary of HEW, [and] 42 C.F.R. § 1.103 [which] was duly promulgated and in force from 1951 through 1978." *Begay*, 591 F.Supp. at 1011. HEW is a cabinet level executive agency which includes the Surgeon General's Office. The regulation, 42 C.F.R. § 1.103(c)(2), states the following:

> 2) *Information and data obtained and tentative and final conclusions reached in the course of* or in connection with the conduct of research projects, surveys and investigations may be disclosed at such times and to such extent as the Surgeon General or his designee may *determine to be in the public interest* (Emphasis supplied).

The decision not to release information taken from the study done by the PHS, under the Surgeon General's authority, is the type of decision covered by the exception. A review of that decision by this court would be an encroachment into the decision-making process of the executive branch which we decline to undertake. *See Varig*, 104 S.Ct. at 2765.

As we outlined above, if the decision by the agency is based on social, economic, or political policy considerations, then review by the court would consist of judicial second-guessing of the agency decision. Section 1.103(c)(2) expressly states that the Surgeon General or his designee may decide, *if in the public interest*, not to disclose certain information. Such a decision is discretionary by its very nature.

It is now well known that "there is a direct relationship between the high levels of radiation exposure suffered by the underground uranium miners and their excessive incidence of respiratory tract and lung cancer." *Begay*, 591 F.Supp. at 1006. At the time of the PHS study, however, the extent of danger in uranium mining was not known. In order to continue that study, a discretionary decision not to warn the miners of the possible radiation dangers of uranium mining was made.[1]

The PHS and the other federal and state agencies hypothesized that exposure to radiation in the uranium mines may have presented a danger to the miners. After 1959, the statistical data also indicated that the danger was present. The PHS staff, limited in both funds and authority, still did not warn the miners of the increasing evidence of radiation danger in the uranium

1. We believe that the decision here exemplifies the type of decision in the hypothetical given by the district court, below:

> Suppose a high level decision maker says, "International pressures make opening secret testing highly necessary. Time is of the essence. We know as a result of such testing some people are going to get hurt. We can't tell them they are going to get hurt. We can't even warn them what to do to minimize or prevent the hurt. In order to preserve our way of life some people unknown to them and unknown to us are going to give all for the good of all."
>
> Policy decision? Yes. Tort Claims Act exemption.

Allen v. United States, No. C 79-0315-J, slip op. at pp. 133-4 (D.Utah 1984). *Begay*, 591 F.Supp. at 1012.

mines. *Begay*, 391 F.Supp. at 995. Even though it may have been suspected by the PHS that some miners would suffer injury from radiation exposure, the goal of the study was to determine the extent of the hazards so that recommendations could be made and standards promulgated. This type of decision, one not to warn, was clearly the type of decision of an agency which Congress sought to protect from judicial review under the Tort Claims Act.

CONCLUSION

The analysis of the factors we have presented in this case shows that the decision of the Public Health Service not to warn the plaintiffs of the radiation dangers they were exposed to, is clearly within the ambit of the discretionary function exception, 28 U.S.C. § 2680(a). We agree with the district court that this is the type of case that cries out for redress, but the courts are not able to give it. Congress is the appropriate source in this instance.

The judgment of the district court is AFFIRMED.

COLUMBIA BRICK WORKS, INC., Plaintiff-Appellee,

v.

ROYAL INSURANCE COMPANY OF AMERICA, Defendant-Appellant.

No. 84-4128.

United States Court of Appeals, Ninth Circuit.

Argued and Submitted May 6, 1985.
Decided Aug. 13, 1985.

Marine cargo insurer appealed from judgment of the United States District Court for the District of Oregon, Robert C. Belloni, J., awarding prejudgment interest on marine cargo insurance claim. The Court of Appeals, Sneed, Circuit Judge, held that: (1) prejudgment interest could be computed on basis of entire jury award, (2) prejudgment interest could be awarded from date of delivery; and (3) district court did not abuse its discretion in applying interest rate of 12.801%, the 52-week Treasury bill rate on the date of delivery.

Affirmed.

Wallace, Circuit Judge, filed a concurring statement.

1. Interest ⇐38(1), 39(2.25)

In admiralty law, district court has discretion to award prejudgment interest to accomplish just restitution of injured parties and also has broad discretion to determine when prejudgment interest commences and what rate of interest to apply.

2. Admiralty ⇐118.5

In admiralty cases, Court of Appeals reviews district court's grant of prejudgment interest for abuse of discretion.

3. Interest ⇐39(2.25)

In admiralty case, discretion is abused in award of prejudgment interest if award amounts to penalty rather than compensation.

4. Interest ⇐39(2.25)

In admiralty case, award of prejudgment interest is prohibited that either duplicates item of compensation already awarded or compensates for loss either that never will be suffered or that has not been suffered prior to judgment.

5. Interest ⇐39(2.25)

Prejudgment interest is not allowable in admiralty case when compensation for losses that occurred prior to judgment already has been computed by method that includes interest at proper rate from date of injury nor is prejudgment interest allowable with respect to losses that will accrue subsequent to judgment.

RCJY-64-89

EXHIBIT "A"

RESOLUTION OF THE RESOURCES COMMITTEE
OF THE NAVAJO TRIBAL COUNCIL

Supporting the United States Senate Bill S.841, and its Companion House of Representatives bill H.R.2372, the Radiation Exposure Compensation Act, to Provide Jurirdiction and Procedures for Claims for Compassionate Payments for Injuries Due to Exposure to Radiation from Uranium Mining

WHEREAS:

1. The Resources Committee is a standing committee of the Navajo Tribal Council, which is charged with addressing all natural resources issues within the Navajo Nation; and

2. There has for several years been a clear need to provide some degree of reparation to Navajo uranium miners, their families and all other Navajo people whose health and lifestyle who have been adversely affected by the uranium mining activities, particularly, those miners who have suffered the effects of lung cancer and other diseases caused by their work mining uranium in the 1950's and 60's;and

3. These miners played a vital role to mine uranium that was used to fuel the U.S. Government's nuclear program; and

4. Even though the U.S. Government had adequate warning of the hazards involved, Navajo miners were sent into inadequately ventilated mines with no instruction regarding the dangers of radiation exposure; and

5. The U.S. Government should provide these miners with a proper legal remedy.

NOW THERFFORE BE IT RESOLVED THAT:

1. The Resources Committee of the Navajo Tribal Council hereby strongly supports the passage of Senate bill S.841 and its companion House of Representatives bill H.R. 2372, the Radiation Exposure Compensation Act, to provide jurisdiction and procedures for claims for compassionate payments for injuries due to exposure to radiation from uranium mining.

2. The Resources Committee recommend that language be included in the proposed legislation that immediate families and descendents of the uranium mine workers affected by radiation exposure and/or disabilities and d ease caused genetically through the contaminated environment and wate: be compensated.

3. The Resources Committee further recognizes that some language in the proposed legislation should be refined and will make recommendations to the U.S. Congress as the proposed legislation moves through the legislative process.

RCMY-64-89

4. The Resources Committee further urges that all Members of the Arizona, New Mexico and Utah delegations respectively co-sponsor S.841 and H.R.2372.

5. The Resources Committee further requests that Congressional Field hearings on the bill be held in Shiprock, New Mexico which is near the Communities in New Mexico and Arizona in which most of the former miners and their families reside.

6. The Resources Committee further requests the Navajo Tribal Council to support this resolution.

C-E-R-T-I-F-I-C-A-T-I-O-N

I, the undersigned, hereby certify that the foregoing resolution was duly considered by the Resources Committee of the Navajo Tribal Council at a duly called meeting in the Division of Natural Resources Conference Room at Window Rock, Navajo Nation (Arizona), at which a quorum was present and that same was passed by a vote of 5 in favor and 0 opposed, this 14th day of August, 1989.

Ernest H. Begay, Chairman
Resources Committee

MOTIONED: Benjamin A. House
SECONDED: Samuel Yazzie

CN-62-89

Class "C" Resolution
No BIA Action Required.

RESOLUTION OF THE
NAVAJO TRIBAL COUNCIL

Supporting the United States Senate Bill S.841, and its Companion House of Representatives Bill H.R.2372, Bills to Provide Jurisdiction and Procedure for Claims for Compassionate Payments for Injuries Due to Exposure to Radiation from Uranium Mining and Related Actions (Radiation Exposure Compensation Act)

WHEREAS:

1. The Navajo Tribal Council is the governing body of the Navajo Nation; and

2. There has for several years been a clear need to provide some degree of reparation to all Navajo people whose health and lifestyles have been adversely affected by the uranium mining activities on the Navajo Nation; particularly, those miners who have suffered the effects of lung cancer and other diseases caused by their work mining uranium in the 1950's and 1960's; and

3. Nuclear testing, underground mining and mill processing for uranium ore were actually undertaken and encouraged by and for the United States Government since the 1940's; and

4. These miners played a vital role in mining uranium that was used to fuel the United States Government's nuclear program; and

5. The Navajo uranium miners have developed and will probably develop health problems directly attributable to working in the area of high radiation leaks and unvented mines, such as lung cancer and silicosis; and

6. The United States Government should provide these miners with a proper legal remedy; and

7. By Resolution RCJY-64-89 (attached hereto as Exhibit "A" and made a part hereof), the Resources Committee of the Navajo Tribal Council has supported the Senate Bill S.841, (attached hereto as Exhibit "B" and made a part hereof), and its companion House of Representatives Bill H.R.2372, the Radiation Exposure Compensation Act.

MEXICAN WATER CHAPTER
RESOLUTION OF MWCR-006-19182-89

SUPPORTING THE RADIATION EXPOSURE COMPENSATION ACT, INTRODUCED AS S. 841 BY SENATOR ORRIN HATCH (R-UTAH)

WHEREAS:

1. The Mexican Water Chapter is empowered as a certified governmental body of the Navajo Nation, is authorized to represent and act in the best interest of the safety, health and general welfare of the local Navajo residents;

2. The Mexican Water Chapter is adversely impacted by activities of past underground uranium mines from 1940 to 1960's;

3. That due to lack of enforcements of health and safety standards during this time frame, many local miners were needlessly exposed to levels of radioactivity far exceeding Federal and United States Environmental Protection Standards for exposures to ionizing radiation;

4. That, as a result, many former miners are deceased and/or currently suffer disabling lung cancers and diseases;

5. Furthermore, families and dependents of these former miners also exhibit varying degrees of birth anomalies and defects.

THEREFORE, BE IT RESOLVED THAT:

1. The Mexican Water Chapter Community supports introduction and passage of S. 841 through the United States Congressional and the House Of Representative bodies;

2. The Mexican Water Chapter community also requests supportive and coordinative efforts from the Navajo Tribal Council for S. 841.

C E R T I F I C A T I O N

We, hereby certify that the foregoing resolution was duly considered by the Mexican Water Chapter community, at a regularly called meeting at Mexican Water Chapter, Navajo Nation, Arizona at which a quorum was present and that same was passed by a vote of 28 in favor and 0 opposed on this 06th day of August, 1989.

DAVID YAZZIE, Chapter President

DEAN PAUL, Council Delegate

DAVID JOHN, Vice-President

JAMES TSOSIE, Secretary/Treasurer

LOUIS TAPAHA, SR., CHAPTER PRESIDENT

DEAN PAUL, SR., COUNCIL DELEGATE

JONAS HASTACH, CHAPTER VICE-PRESIDENT

HERMAN FARLEY, CHAPTER MANAGER

EDVARD TAPAHA, CHAPTER SECRETARY/TREASURER

FEB - 2 1989
CHAPTER GOVERNMENT
NATION BLDG. PROGRAM

RESOLUTION OF THE BECLABITO
COMMUNITY CHAPTER, SAN JUAN COUNTY, NEW MEXICO

SUPPORTING THE RADIATION EXPOSURE COMPENSATION ACT OF 1989, INTRODUCED AS S.2633 BY SENATOR ORRIN HATCH (R-UTAH) AND HR 5022 BY CONGRESSMAN WAYNE OWENS (D-UTAH)

WHEREAS:

1) The Beclabito Community Chapter is impacted by activities of past underground uranium mines from 1940 to 1960's;

2) That due to non-existence of health and safety standards during this time period, many former miners were needlessly exposed to levels of radioactivities far exceeding current Federal and United States Environmental Protection Agency Standards;

3) That, as a resultant of their exposures, many are deceased and/or currently exhibit disabling lung cancers or lung diseases;

4) Furthermore, families and dependents of these former miners also exhibit varying degrees of birth anomalies and defects;

5) That as a certified Chapter authorized to administer governmental functions per 2 N.T.C. 4001 passed by Resolution C.M.Y. 23-79, the Beclabito Community Chapter does represent and support the best interest, safety, health and general welfare of the local Navajo residents.

THEREFORE, BE IT RESOLVED THAT:

1) The Beclabito Community Chapter supports introductions and passages of both S.2633 and HR 5022 through the United States Congress and House of Representative bodies;

2) The Beclabito Community Chapter also requests supportive and coordinative efforts from the Navajo Tribal Council for S.2633 and HR 5022.

CERTIFICATION

We, hereby certify that the foregoing resolution was duly considered by the Beclabito Community Chapter, at a regularly duly called meeting at Beclabito Chapter, Navajo Nation, New Mexico, at which a quorum was present and that same was passed by a vote 12 in favor and 0 opposed on this 24 day of January, 1989.

Jerry Benally, President

Rosemary Lee, Secretary/Treasurer

Frank John, Sr., Vice-President

Robert Ahkeah, Committeeman

RECEIVED
APR - 3 1989
CHAPTER GOVERNMENT
NATION BLDG PROGRAM

CERTIFICATION

We, hereby certify that the foregoing resolution was duly considered by the District 12 Council of the Navajo Nation at a duly called meeting at Shiprock, New Mexico at which a quorum was present and that same was passed by a vote of 14 in favor and 0 opposed, this 01 day of April, 1989.

Lee B. Kay, Chairman

Jerry Bonelly, Vice-Chairman

Larry Yazzie, Secretary

RED MESA CHAPTER

RED MESA, NAVAJO NATION, UTAH

REDM-89-069

RED MESA

R E S O L U T I O N

Louis Topaha, Sr., Chapter President
Isaac Mariano, Vice President
Edward Topaha, Secretary/Treasurer

Dean Paul Sr., Grazing Delegate
Norman Patsey, Chapter Manager

SUPPORTING THE RADIATION EXPOSURE COMPENSATION ACT, INTRODUCED AS S.2833 BY SENATOR ORRIN HATCH (R-UTAH) AND HR.5022 BY CONGRESSMAN WAYNE OWENS (D-UTAH).

WHEREAS:

1. The Red Mesa Chapter is empowered as a certified government body of the Navajo Nation, is authorized to represent and act in the best interest of the safety, health and general welfare of the local Navajo residents; and

2. The Red Mesa Chapter is adversely impacted by activities of past underground uranium mines from 1940 to 1980's; and

3. That due to lack of enforcements of health and safety standards during this time frame, many local miners were needlessly exposed to levels of radioactivities far exceeding Federal and United States Environmental Protection Standards for exposures to ionizing radiation; and

4. That, as a result, many former miners deceased and/or currently suffer disabling lung cancers and diseases; and

5. Furthermore, families and dependents of these former miners also exhibit varying degrees of birth anomalies and defects.

THEREFORE BE IT RESOLVED THAT:

1. The Red Mesa Community Chapter supports introductions and passages of both S.2833 and HR 5022 through the United States Congressional and a House of Representative bodies; and

2. The Red Mesa Community Chapter also requests supportive and coordinative efforts from the Navajo Tribal Council for S.2833 and HR. 5022.

C E R T I F I C A T I O N

We hereby certify that the foregoing resolution was duly considered by the Red Mesa Chapter at a duly called meeting at Red Mesa, Navajo Nation, Utah at which a quorum was present and that same was passed by a vote of 35 in favor and 0 opposed, this 22nd day of April, 1989.

Post Office Box 485 Montezuma Creek, Utah 84534 Phone: (801) 651-3292

RESOLUTION OF THE TEECNOSPOS
COMMUNITY CHAPTER, NAVAJO NATION, TEECNOSPOS ARIZONA

SUPPORTING THE RADIATION EXPOSURE COMPENSATION ACT, INTRODUCED AS S.2633 BY SENATOR ORRIN HATCH (R-UTAH) AND HR.5022 BY CONGRESSMAN WAYNE OWENS (D-UTAH).

WHEREAS:

1. The TEECNOSPOS Chapter is empowered as a certified governmental body of the Navajo Nation, is authorized to represent and act in the best interest of the safety, health and general welfare of the local Navajo residents;

2. The TEECNOSPOS Chapter is adversely impacted by activities of past underground uranium mines from 1940 to 1960's;

3. That due to lack of enforcements of health and safety standards during this time frame, many local miners were needlessly exposed to levels of radioactivities far exceeding Federal and United States Environmental Protection Standards for exposures to ionizing radiation;

4. That, as a result, many former miners are deceased and/or currently suffer disabling lung cancers and diseases;

5. Furthermore, families and dependents of these former miners also exhibit varying degrees of birth anomalies and defects.

THEREFORE, BE IT RESOLVED THAT:

1. The TEECNOSPOS Community Chapter supports introductions and passages of both S.2633 and HR 5022 through the United States Congressional and a House of Representative bodies;

2. The TEECNOSPOS Community Chapter also requests supportive and coordinative efforts from the Navajo Tribal Council for S.2633 and HR 5022.

CERTIFICATION

We, hereby certify that the foregoing resolution was duly considered by the TEECNOSPOS Community Chapter, at a regularly called meeting at TEECNOSPOS Chapter, Navajo Nation, TEECNOSPOS at which a quorum was present and that same was passed by a vote of 44 in favor and 00 opposed on this 6th day of February, 1989.

President

Secretary/Treasurer

Vice-President

Council Delegate

27-762

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RESOLUTION OF THE FORMER NAVAJO URANIUM MINERS
TONALEA CHAPTER
THE NAVAJO NATION

SUPPORTING THE "RESOLUTION OF THE FORMER NAVAJO URANIUM MINERS, TONALEA CHAPTER, THE NAVAJO NATION" FOR ITEM NO. 6 AND ITEM NO. 4 (RESPECTIVELY):

IN REFERENCE TO "RADIATION EXPOSURE COMPENSATION ACTS," INTRODUCED AS S. 841 AND ITS COMPANION BILL H.R.2172, AS WELL AS OTHER PROPOSED BILLS, THAT PROVIDE JURISDICTION AND PROCEDURES FOR CLAIMS ON DAMAGES AND INJURIES RECEIVED DUE TO RADIATION FROM URANIUM MINING.

The following addresses the Bill S.841 and Bill H.R. 2172 regarding "Radiation Exposure Compensation Act" on behalf of all Uranium Mill Workers in the Four Corners Area in the 1950 era. Specifically, these workers were directly exposed to a variety of Uranium Composition in the Mill Plant throughout localities. Furthermore, it has victimized them with various psychological and physiological ailments and some have "Paid the Price," with their lives, to serve the National Security interests of the United States Government, through employment at various Uranium Mill Plant sites, whom has insufficient knowledge of the latency effects of radiation exposure.

WHEREAS:

1) According to testimonies through congregated meetings held with past Uranium Mill Workers in the 1950 era, it is understood that Uranium Processing Mill Workers were by far more exposed to raw (yellow cake form) form of Uranium. Therefore the latency effects exceeds the latency effects prescribed for a underground Mine Worker.

2) Specifically, justifing with evidential proof is employees who worked in the Scale House, Ore Yard, Sample Plant, Crushing Plant, Grinding Circuit, Flotation Circuit, Uranium Leaching Circuits, Counter-Current Washing of Barren Solids, Solvent Extraction, Yellow Cake Precipitation, Tailings Disposal have actually handled uranium in a highly raw form, throughout other mill sites without set EPA approved safety protectants, devices, etc.

3) The victimized are also wives and children of mill employees, by transmitting worksite contamination at homesteadings. Another is by residing near mill site premises.

4) The most concern lies where the United States Government, deliberately allowed the Jeopardization of the lives of all mill workers through "prolonged radiological exposure." (In reference of Resolution of the Former Navajo Uranium Miners, Tonalea Chapter, The Navajo Nation-Item No. 6 and Item No. 4.)

THEREFORE BE IT RESOLVED THAT:

1) Former Uranium Mill Workers be included into both Bill S.841 and H.R.2172, therefore subject to the same administrative

jurisdiction and procedures for claims on their damages and injuries.

CERTIFICATION

We hereby certify that the foregoing resolution was duly considered by Tonalea Chapter at a duly called meeting at Tonalea, (Navajo Nation), Arizona at which a quorum was present and the same was passed by a vote of 117 in favor and 2 opposed on this 3rd day of October, 1989.

John Fowler, Chairman Pro-Tem

Mike Kiyaani, Vice-Chairman Pro-Tem

Linda Fowler, Secretary

RESOLUTION OF THE FORMER NAVAJO URANIUM MINERS
WESTERN NAVAJO AGENCY
THE NAVAJO NATION

SUPPORTING "THE RADIATION EXPOSURE COMPENSATION ACTS," INTRODUCED AS S. 841 AND ITS COMPANION BILL H.R. 2372, AS WELL AS OTHER PROPOSED BILLS, THAT PROVIDE JURISDICTION AND PROCEDURES FOR CLAIMS ON DAMAGES AND INJURIES RECEIVED DUE TO RADIATION EXPOSURE FROM URANIUM MINING.

WHEREAS:

1) Former Navajo uranium miners of the 1940's to 1970's mining era within the Four Corners area, in a united effort are addressing their support and concern on issues relating to current attempts to introduce compensation bills that would provide damage awards;

2) There has been for many years, a clear need to provide reparation in terms of monetary settlements and provisions of better health care for uranium miners afflicted with lung cancer and other serious respiratory disease, as a direct result of exposure to radioactivity while engaging in underground uranium mines;

3) That the United States Government, as the sole procurer of the uranium ore, had adequate knowledge of the hazards involved, deliberately allowed prolonged radiological exposure of the Navajo miners, even to the point of retaining the Navajo miners as an exculpatory study group;

4) The Navajo uranium miners played a vital role in assuring the success of American's nuclear industries, at the expense of their health, their lives and those of their families;

5) These miners agree with the August 1985 administrative decision initiated by the United States Court od Appeals, Ninth Circuit, where the court "agree with the District Court that this is the type of case that cries out for redress, but the courts are not able to give it[.] Congress is the appropiate source in this instance." (John Begay, et al.; vs. United States of America; Stewart L. Udall, Phoenix, Arizona for Plaintiffs/Appellants, No. 84-2462);

6) That the former uranium miners recognize that mill workers were also exposed to uncontrolled amount of radioactivity during the ore processing procedures and that the mill workers are not included in S. 841 and H.R. 2372.

THEREFORE BE IT RESOLVED THAT:

1) The Navajo uranium miners do hereby fully support the Radiation Exposure Compensation Acts, S. 841 and H.R. 2372 and all other future bills that would provide jurisdiction and procedures for claims on damages/injuries received due to radiation exposures from underground uranium mining activities;

2) In addition to monetary relief, the United States Government is obligated to provide immediate relief in improving health care specifically designed for former uranium miners and their families.

3) Navajo uranium miners, also recognizing that certain language in both S. 841 and H.R. 2372 require modifications, urge the Navajo Tribal Council to assist in such modifications, provide supportive efforts of both Bills, and urge the Navajo Tribal Council to contact and urge respective delegate members of the states of Arizona, Colorado, New Mexico, and Utah to co-sponsor both Bills.

4) Former mill workers be included into both S. 841 and H.R. 2372 subject to the same administrative jurisdiction and procedures for claims on their damages and injuries.

5) The Navajo uranium miners also request a Public Hearing on both Bills to be held in and conducted on the Navajo Reservation and that all appropiate Tribal entities provide expert assistance and witnesses to accomplish this.

C E R T I F I C A T I O N

We hereby certify that the foregoing resolution was duly considered by the Navajo uranium miners, at a special called public meeting held at Tonalea Community Chapter House, Tonalea, Navajo Nation, Arizona, at which this resolution was passed by a vote of 47 in favor, 0 opposed and 0 abstentions, on this 31 day of October, 1989.

John Fowler, Chairman: Protempore

Mike Kiyaani, Vice Chairman: Protempore

Linda L. Fowler, Secretary: Protempore

4) former mill workers be included into both S.861 and H.R.2372 subject to the same administrative jurisdiction and procedures for claims on their damages and injuries.

5) The Navajo uranium miners also request Public Hearing on both bills to be held in and conducted on the Navajo Reservation, preferrable at Shiprock, New Mexico and that all appropriate Tribal entities provide expert assistance and witnesses to accomplish this.

CERTIFICATION

We hereby certify that the foregoing resolution was duly considered by the Navajo Uranium Miners, at a special called public meeting held at Mexican Water Chapter House, Navajo Nation, at which this resolution was passed by a vote of 280 in favor, 0 opposed and 0 abstentions, on this 4th day of September, 1989.

David Jonn
Chairman: Protempore

Perry n. Charley
Vice-Chairman: Protempore

Lee B. Roy
Secretary: Protempore

RESOLUTION OF THE FORMER NAVAJO URANIUM MINERS
THE NAVAJO NATION

SUPPORTING "THE RADIATION EXPOSURE COMPENSATION ACTS," INTRODUCED AS S.841 AND IT'S COMPANION BILL H.R.2372, AS WELL AS OTHER PROPOSED BILLS, THAT PROVIDE JURISDICTION AND PROCEDURES FOR CLAIMS ON DAMAGES/INJURIES RECEIVED DUE TO RADIATION EXPOSURES FROM URANIUM MINING.

WHEREAS:

1) Former Navajo uranium miners of the 1940's to 1970's mining era within the Four Corners area, in a united effort are addressing their support and concern on issues relating to current attempts to introduce compensation bills that would provide damage awards,

2) There has been for many years, a clear need to provide reparation in terms of monetary settlements and provisions of better health care for uranium miners afflicted with lung cancer and other serious respiratory disease, as a direct result of exposure to radioactivity while engaging in underground uranium mines,

3) That the United States Government, as the sole procurer of the uranium ore, had adequate knowledge of the hazards involved, deliberately allowed prolonged radiological exposure of the Navajo miners, even to the point of retaining the Navajo miners as an exculpatory study group,

4) The Navajo uranium miners played a vital role in assuring the success of American's nuclear industries, at the expense of their health, their lives and those of their families,

5) These miners agree that the United States Government is morally and legally obligated to provide monetary relief and better health care for the Navajo uranium miners and their families,

6) That the former uranium miners recognize that mill workers were also exposed to uncontrolled amount of radioactivity during the ore processing procedures and that the mill workers are not included in S.841 and H.R.2372.

THEREFORE BE IT RESOLVED THAT:

1) The Navajo uranium miners do hereby fully support the Radiation Exposure Compensation Acts, S.841 and H.R.2372 and all other future bills that would provide jurisdiction and procedures for claims on damages/injuries received due to radiation exposures from underground uranium mining activities,

2) In addition to monetary relief, the United States Government is obligated to provide immediate relief in improving health care specifically designed for former uranium miners and their families,

3) Navajo uranium miners, also recognizing that certain language in both S.841 and H.R.2372 require modifications, urge the Navajo Tribal Council to assist in such modifications, provide supportive efforts of both Bills, and urge the Navajo Tribal Council to contact and urge respective delegate members of the states of Arizona, Colorado, New Mexico, and Utah to co-sponsor both Bills,

NOW THEREFORE BE IT RESOLVED THAT:

1. The Navajo Tribal Council hereby strongly supports the passage of Senate Bill S.841, Exhibit "B", and its companion House of Representatives Bill H.R.2372, to provide jurisdiction and procedures for claims for compassionate payments for injuries due to exposure to radiation from uranium mining (Radiation Exposure Compensation Act).

2. The Navajo Tribal Council recommends that language be included in the proposed legislation that the immediate families and descendants of the uranium mine workers affected by disabilities and diseases caused by genetic radiation exposure and the radiation contaminated environment, buildings and water be compensated.

3. The Navajo Tribal Council further recognizes that some language in the proposed legislation should be refined and will make recommendations to the United States Congress as the proposed legislation moves through the legislative process.

4. The Navajo Tribal Council further urges that all members of the Arizona, New Mexico and Utah delegations, respectively cosponsor S.841 and H.R.2372.

5. The Navajo Tribal Council further requests that Congressional field hearings on the bill be held in Shiprock, New Mexico and Tuba City, Arizona, which is near the communities in New Mexico and Arizona in which most of the former miners and their families reside.

6. The Navajo Tribal Council furthermore hereby strongly and respectfully urges the United States Congressional committees on appropriation to support the funding to accomplish the intent of this proposed legislation.

7. The Navajo Tribal Council further recommends bill language to include compensation for uranium mill workers.

CERTIFICATION

I hereby certify that the foregoing resolution was duly considered by the Navajo Tribal Council at a duly called meeting in Window Rock, Navajo Nation (Arizona), at which a quorum was present and that same was passed by a vote of 62 in favor and 0 opposed, this 22nd day of November, 1989.

Interim Chairman
Navajo Tribal Council

Statement of Earl Mettler

before the

Senate Committee on Labor and Human Relations

February 8, 1990

Through my office at Shiprock, New Mexico, on the Navajo Reservation, I have known and worked with a number of former uranium miners and their families. Most of the Navajo uranium miners began working in mines in the Four Corners area in the 1950s or 1960's, and followed the work to wherever mines were in operation, usually ending their careers in Colorado mines in the 1970's.

These men worked in grossly unsafe conditions. They worked underground in mines that were poorly ventilated. They have reported to me that they were often forced to go into shafts very shortly after blasting, when the air was extremely dusty. They were not provided with protective clothing or air masks. Tolan, "Uranium Plagues the Navajos," Sierra, November/December 1983. One physician who treated Navajo miners has said, "Exposure was so intense in those early uranium mines that it's almost hard to conceive of it. It was like lying under an x-ray machine day and night for six months." Barry, "The Navajo Nation: Living and Breathing Radioactivity," Akwasasne Notes, Autumn 1979.

I have seen measurements of radiation exposure for individual miners that are routinely several hundred "working level months," indicating extremely high cumulative radiation exposures. I have been personally acquainted with several former miners who contracted and died of lung cancer during the time that I knew them.

The mine conditions, their health effects on the miners, and the federal role in failing to prevent the tragic consequences to the miners have been documented in the court decisions in Begay v. United States, 591 F.Supp. 991 (D.Az. 1984) and Begay v. United States, 768 F.2d 1059 (9th Cir. 1985). These cases denied a federal tort remedy to a group of Navajo miners and their families.

I have worked with miners and their families on claims for compensation under state worker's compensation laws. These laws do not provide an adequate remedy for several reasons, some of which are the following:

--Proof requirements in some states are overly restrictive. In New Mexico, for instance, the disease must manifest itself within ten years from when the miner last worked, a requirement

that is at odds with medical knowledge about the latency period of cancer.

--Statutes of limitation bar many claims because the miners and their widows are uneducated, do not speak English, do not understand the medical cause of their illness and have not had access to legal advice.

--State worker's compensation laws require that an action be filed against the last employer, but many last employers are no longer in business, there are no records of their insurance coverage, or there are no records that identify the last company a man worked for.

--Finally, if all obstacles can be overcome and there is a recovery, the level of compensation is a percentage of the earnings in the mining employment. Since that work will often have been done many years ago, the compensation level is quite low. In several of the cases I have handled, compensation to a widow for the death of a miner has been less than $100 per month.

The unavailability of a tort remedy, and the inadequacy of a worker's compensation remedy, combined with the tragedy of the treatment of the miners, prompted both of the courts hearing the Begay cases, cited above, to call for a Congressional enactment to establish a remedy. The Ninth Circuit stated as follows:

> We agree with the district court that this is the type of case that cries out for redress, but the courts are not able to give it; Congress is the appropriate source in this instance.

768 F.2d, 1066.

A compensation program was proposed by Sen. Domenici in the 95th Congress. Hearings were held in 1979 and 1980. Testifying before the Senate Labor and Human Resources Committee on August 27, 1980, Sen. Domenici stated that "significant numbers of Navajo miners were experiencing disabling and all too frequently fatal illnesses, primarily lung cancers" attributed to mining. He noted that the plight of the miners was a long-standing one, having been documented by the Surgeon General in 1967. In a 1979 Senate Judiciary Committee hearing, testimony showed that there had been 144 cancer deaths among uranium miners. I know of several more miners who have died of cancer since then. As Sen. Domenici said in his 1980 hearing testimony,

> I am still receiving letters from uranium miners who have recently been stricken with lung cancer and other mine-related diseases and from the relatives of those who have just recently died. These men are still paying--with their health and with their lives -- for

> the federal government's inaction during these two decades in the area of uranium mine health and safety.

Testimony of Sen. Domenici before the Senate Labor and Human Resources Committee, August 27, 1980.

Thus, the rightness of a federal remedy is clear, and the need for it is compelling.

Thank you for allowing these comments to be submitted in connection with the bill.

PREPARED STATEMENT OF STEWART L. UDALL

I am a lawyer and I am submitting this statement on behalf of clients I and about fifteen other lawyers have represented in the federal courts of the United States for over a decade. They include approximately 900 families who lived downwind from the Nevada Test Site, over 200 Navajo Indians who are widows of deceased Navajo miners or living miners who worked in uranium mines on the Colorado Plateau, and about 30 non-Indian widows of miners or living miners who worked in uranium mines in and about Marysvale, Utah.

Nearly all of these victims filed claims against the United States pursuant to provisions of the Federal Tort Claims Act (FTCA) and were plaintiffs in actions subsequently filed against the government in federal district courts. Thereafter (in some instances after lengthy trials), these victims were denied access to justice and cast out of the federal courts as a result of rulings based on judicial findings that when Congress enacted the FTCA in 1946, it intended that the United States should be shielded from liability under the doctrine of sovereign immunity.

These courts have effectively pronounced that "the King can do no wrong" -- that there are some things that are

more important than justice. This collective pronouncement has been made notwithstanding the fact that some of the federal judges either found in favor of some of these victims or wrote agonizing opinions in which they affirmed that the sacrifices made by these citizens "cry out for redress." Indeed, some of these judges were so appalled by the outcome that they included words in their written opinions counselling these victims to seek such redress from the Congress of the United States.

But these federal courts were not the only ones to direct these victims to Congress. In 1980 the House Subcommittee on Oversight and Investigations of the Committee on Interstate and Foreign Commerce conducted an exhaustive probe into the circumstances surrounding the testing in Nevada. The subcommittee not only unanimously found that the government was guilty of egregious negligence but concluded their report with this macabre observation: "The greatest irony of our atmospheric nuclear testing program is that the only victims of U.S. nuclear arms since World War II have been our own people."

And so, these victims come to you at the end of a very long trail. These are the victims of the government's negligence in the first reckless phase of the atomic age. These victims were, in different guises, unwitting soldiers of the cold war whose lives were sacrificed as a direct result of actions taken by federal officials who were in charge of programs that were integral elements of vital

national security activities of our government. These victims are the human debris of the cold war. Now, as we approach the end of the cold war, I urge you to admit the federal government's past mistakes and salute these tragic soldiers with a compassionate gesture.

Objections have been raised by the Department of Justice (DOJ) with respect to the proposed Radiation Exposure Compensation Act. The objections, stated in testimony before the Subcommittee on Administrative Law and Governmental Relations of the House Judiciary Committee last November, are primarily two-fold.

First, DOJ argues that there is no scientific evidence to show that the injuries sustained by the victims are the result of radiation exposures generated by activities of the federal government. There is, however, an overwhelming abundance of scientific evidence. Moreover, the federal judges who sat in judgment in the lawsuits brought by these victims -- and members of the House of Representatives who investigated the tragedies of the downwinders -- found in many instances that the victims' injuries were caused by federal activites and that the evidence of medical causation was overwhelming.

Indeed, in the case of the uranium miners, the Public Health Service used the miners as guinea pigs to study the effects of radiation. The principal investigator of that study, Dr. Victor Archer, presented his findings to this Committee that the uranium miners were exposed to

extraordinary levels of radiation that caused lung cancer and other nonmalignant respiratory diseases.

The DOJ has also argued that the proposed Radiation Exposure Compensation Act would unnecessarily provide payments to persons who can pursue worker compensation remedies. Such an objection completely ignores the reality of these victims. Most of the Navajo uranium miners were uneducated, did not speak English and lived in very remote areas within the Navajo Nation. With very few exceptions, these victims did not pursue this remedy because they knew nothing about their legal rights. By the time many became aware of the existence of worker's compensation, the statute of limitations had run. For others the remedy has been unavailable because their last place of employment is no longer in existence or its insurance records cannot be located. For those who have been fortunate enough to avail themselves of the remedy, awards have proven grossly inadequate, in some cases less than $100 per month.

The case of the Navajo uranium miners is one of egregious government malfeasance. The federal government has a special trust relationship with respect to Indian tribes. It owes a special duty of care to protect them and to provide for their health care. The Atomic Energy Commission (AEC) and the Public Health Service (PHS) violated this special duty of care by not warning the Navajos and ensuring their protection.

As is more thoroughly explained in the attached draft of a chapter I have written for a book about the numerous avoidable tragedies of the atomic age, the AEC and PHS knew of the perils of uranium mining from the beginning of the mining period. From the outset they also knew that adequate ventilation of the mines would alleviate most of the hazards. In its mad rush to expedite the output of uranium for the nuclear weapons program, the AEC callously sent these innocent citizens to their deaths.

The AEC dropped a curtain of secrecy. It hid behind the canard that it was premature to draw conclusions about radiation hazards in U.S. mines until the PHS epidemiologists reported there were sufficient deaths to demonstrate that there was a lung cancer epidemic on the Colorado Plateau. It repeatedly pretended that, like a good neighbor, it was doing its best to help the states and the mining companies come to grips with their mine safety problems. Such abdication, however, was lethal to the Navajos because the states had no authority to regulate mine safety on the reservation.

The AEC had the funds, knowledge and power to ensure miners were protected from mining dangers. The federal government entrusted development of uranium resources and public protection to the AEC in the Atomic Energy Act of 1946. The AEC had direct control over mining procedures and methods of operation by writing standards into ore-procurement contracts or by requesting the Department of Labor to use its authority under the Walsh Healy Public

Contracts Act to fix and enforce standards. The AEC took a regulatory posture with respect to beryllium (also used in nuclear weapons production) just shortly before this mining era. However, rather than imposing burdens on mining companies, and potentially slowing production, it kept a shield of secrecy over the uranium mining safety hazards. Until mid-1971, when regulations promulgated under the Metal and Nonmetallic Mine Safety Act of 1966 were fully implemented, uranium miners were exposed to hazardous levels of radiation.

To simplify your task in analyzing the merits of the claims of Navajo and Marysvale miners, I have appended the following documents to my statement:

As Exhibit A, Fact Sheets I have prepared consisting of questions and answers covering the key issues in the cases.

As Exhibit B, a draft of a chapter I have referred to above.

To simplify your task in analyzing the merits of the claims of the downwinders, I have appended the following documents to my statement:

As Exhibit C, quotations from the opinion of the federal judge who tried the fallout case, the Honorable Bruce Jenkins, concerning the crucial issues of negligence and medical causation.

As Exhibit D, excerpts from "The Forgotten Guinea Pigs," the report filed with the House of Representatives by its Subcommittee on Oversight and Investigations in 1980.

(Note: these excerpts also contain the conclusions of the same Subcommittee concerning the government's responsibility for the death of the Utah sheep).

The Navajo uranium miners and the downwinders had no idea they may be harmed. But the federal government knew its activities were causing grave harm. These tragic victims of the nuclear age have been seeking redress for many years. They have appealed to the courts and they have appealed to Congress. And I am puzzled that the federal government has not yet recognized the deadly harm it has done to them. I am especially puzzled because on several occasions this nation has recognized the harm it has done to other nations. On one such occasion this nation recognized the harm atmospheric nuclear tests had done to the people of the Marshall Islands in the Compact of Free Association of 1985.

Mr. Chairman, I believe the legislation this Committee is considering raises a stark moral issue for the President, the Congress, and the American people. Let me state this issue foursquare: WHAT IS THE APPROPRIATE RESPONSE WHEN THE UNITED STATES OF AMERICA HAS CLANDESTINELY KILLED INNOCENT MEN, WOMEN AND CHILDREN WHO ARE ITS OWN CITIZENS?

I am reminded of the response President Abraham Lincoln sent to a distraught mother, who had lost three sons in battle. President Lincoln replied to Mrs. Bixby, "It is a solemn pride that must be yours to lay sacrifice on the alter of freedom." What does the President and the Congress now say to the widows whose dear ones were unwittingly sacrificed on the alter of freedom? The King can do no wrong? It would be too expensive to compensate these victims?

There is nothing so precious as a life and no amount may truly compensate for the suffering these victims have endured. We therefore do not ask you to make these victims whole, but ask you to respond with an apology -- a compassionate payment. We are not asking for a tremendous sum. This class of victims is small, discrete and will not grow. The total cost of the fund proposed by the Radiation Exposure Compensation Act -- $100 million -- is small relative to similar compensation funds recently established by Congress. For example, Congress recently authorized $1.25 billion to compensate Japanese internment victims.

On behalf of these innocent victims, I thank you for hearing their plea that Congress -- and the nation -- recognize the sacrifices they made for their country.

Stewart L. Udall
511 E. Palace Avenue
Santa Fe, NM 87501
(505) 986-9722

EXHIBIT A

FACT SHEET: NAVAJO URANIUM MINERS

FACT SHEET: NAVAJO URANIUM MINERS

I. **Question:** How many claimants are there?

Answer: Approximately 200 widows and disabled miners filed claims against the U.S. under the Federal Tort Claims Act (FTCA).

II. **Question:** Where were the uranium mines located?

Answer: In the Four Corners area of the Navajo Reservation.

III. **Question:** When did the mining begin?

Answer: In 1950. These were some of the first uranium mines in the U.S. The AEC located the ore bodies in the 1940's, offered incentives to private mining companies to open the mines, and was the sole purchaser of the ores.

IV. **Question:** What did these Navajo miners know about uranium mining and its risks?

Answer: They lived in a remote part of their Reservation. Almost all of them were illiterate, and this was their first contact with the American industrial system. They knew nothing about radiation or about health hazards associated with underground uranium mining.

V. **Question:** What federal agencies were charged with executing trust responsibilities toward these Indians?

Answer: The U.S. Public Health Service provided their health care and was in charge of a radiation-protection program at their mines. Entities of the Interior Department controlled mineral leasing and mine-safety in Indian mines.

VI. **Question:** What was the result of the lawsuit filed by the Indians against the United States?

Answer: Federal trial and appellate courts

rom liability by the doctrine of sovereign immunity.

VII. Question: What findings did the trial court make concerning the merits of the claims of the Navajo miners?

Answer: 1) The court found that the lung cancers that killed or disabled the miners was caused by radiation released in the underground mines where they worked.

2) The court also found that "All during the decade of the 1950's the radiation exposures in some mines were found to be more than one-thousand times the maximum working level recommended by the Public Health Service."

VIII. Question: Did the trial court recommend that Congress consider granting relief to these Navajo uranium miners?

Answer: Yes, the judge's written opinion contained this exhortation: "This tragedy of the nuclear age, however; cries for redress. Such relief should be addressed by Congress as it was in the case of the Texas City explosion following the decision of the Supreme court in Dalehite v. U. S. (1953)."

IX. Question : Did the U.S. Court of Appeals recommend that Congress consider granting relief to the miners?

Answer: Yes, that court concluded its written opinion with these words: "We agree with the district court that this is the type of case that cries out for redress, but the courts are not able to give it; Congress is the appropriate source in this instance."

X. Question: Did the Navajos apply for and and receive workmen's compensation benefits under Arizona law?

Answer: With very few exceptions they did not pursue this remedy ~~They did not~~ because they knew nothing about their legal rights.

FACTS SHEET: MARYSVALE URANIUM MINERS

I. Question: How many claimants are there?

Answer: Approximately 30 widows and disabled miners filed claims against the United States under provisions of the Federal Tort Claims Act.

II. Question: Where were the uranium mines located?

Answer: In the vicinity of Marysvale, Utah.

III. Question: When did the mining begin.

Answer: In 1950. These were were some of the first uranium mines in the U. S.. The AEC located the Marysvale ore bodies in the 1940's and offered incentives to private mining companies to open the mines. The AEC was the sole purchaser of the ores from these mines until the mid-60's.

IV. Question: What were the health hazards in the Marysvale mines?

Answer: These mines had some of the highest radiation readings ever recorded in uranium mines. Soon after these miners began working underground in 1950, readings taken by U.S. Public Health Service (PHS) experts revealed radiation concentrations that were 1,000 times higher

than the then current "allowable" levels for U.S. workers exposed to radon gas.

v. Question: What did the PHS experts do to protect the Marysvale miners?

Answer: Their actions -- and inactions -- are described in the affadavit of Duncan Holaday which is attached.

VI. Question: What was the outcome of the lawsuit filed by the Marysvale miners and their widows against the United States?

Answer: Federal trial and appellate courts followed the precedent set in the case of the Navajo Indian uranium miners (see 768 F.2d 1059) and held that the United States was immunized from liability by the doctrine of sovereign immunity. (See...cite 10th Cir. opinion).

VII. Question: Did the Marysvale widows and disabled miners apply for an receive workmen's compensation benefits under Utah law?

Answer: Benefits were denied by Utah courts until the 1980's.

EXHIBIT B

Chapter Outline 5/28/82

WITHERED LEGACY: THE ILLUSIONS, LIES AND UNKEPT PROMISES OF THE ATOMIC AGE

PART ONE

I Myths and the Mythmakers

The atomic age was concieved in secrecy and unveiled with hyperbolic presentations that misled a whole generation.

II The Manhattan Project Plain

Strips away some of the awe and drama. The project itself plucked the fruit of the golden age of physics in the 1930's. It was engineering and applied science...there was no race with Hitler etc.

III Hiroshima: The American Tragedy

IV The Atomic Apparatus and its Apparatchiks

What happens to policymaking in a democracy when a scientific enterprise is authorized to operate in secrecy and is not accountable under the law or normal oversight by Congress.

V The Strange Ride of the Peaceful Atom

PART TWO The Fiascos of America's Atomic Apparat

Introductory Essay: The Atomic Apparat

Historical chapters that tell what happens to science, to scientists and to public policies when an elite is allowed to function above the law under a mantle of secrecy.

VI Tests in the Pacific

* Bikini

* The Voyage of the Lucky Dragon

VII Tests in Nevada

* The Civilians Downwind

* The Apparat and the Irradiated Sheep

* The Scientists Quarrel Over Fallout

VIII Guinea Pigs and Radon Gas

* The Apparat and the Uranium Miners

IX Assaults on Human Health and the Environment by the Nation's Nuclear Weapons Plants

PART THREE

Summation chapters under the general heading "Lessons for the Next Generation."

Final 9/15

THE APPARAT AND THE IRRADIATED SHEEP

"The preplanned strategy of the AEC worked because they had the indiscriminate power to intimidate, to withhold, screen, change and classify any and all information..."

-- Stephen L. Brower
County Agent in 1953

The Spring of 1953 in the Nevada desert the Atomic Energy Commission conducted, as "Operation Upshot-Knothole", eleven atomic explosions. A combination of factors made these the dirtiest, most hazardous detonations ever performed by the AEC at its continental test site. Three of these explosions were more powerful than the war bombs that decimated the cities of Hiroshima and Nagasaki. And the detonation of the bombs on low, 300-foot platforms guaranteed that hundreds of tons of vaporized soil and steel would magnify the "local" fallout over the designated downwind zones in Nevada, Utah and Arizona. (The bombs dropped on Japan were exploded 2,000 feet above the earth -- and the AEC subsequently built towers 500 and 700 feet high at the Nevada Proving Grounds to reduce the local fallout from its high-yield bombs.)

Efforts to cover-up the impacts of the radiation residues produced by the Upshot-Knothole bombs inspired infamous conduct at high levels in the U.S. government -- and produced ugly legal and medical landmarks that will always mar the history of the atomic age.

The fallout from one big bomb, later known as Dirty Harry, "plastered" St. George, Utah, the largest city downwind from the test site and broadcast radiation that produced an epidemic of lukemia in the region a few years later. But that Spring Upshot-Knothole fallout produced a more immediate impact when it killed several thousand sheep. The story of the sheep slaughter has won a special niche in the history of the Atomic Age, for it provided a stage on which the AEC first responded to palpable evidence linking radiation released by its activities to the death of people and animals.

The poisoning of the Utah sheep served as a dress rehearsal where the Atomic Energy Commission could develop techniques to cover up evidence of radiation harm; it also fostered a cabal of high officials in the AEC and senior lawyers in the U.S. Department of Justice who perpetrated a fraud on a federal court as part of an abuse of power that looms as a landmark of infamy in the annals of 20th century American law.

The saga of the irradiated sheep ultimately encompassed four distinct episodes of action and developed, in and out of the courts of law, scientific disputes and legal controversies that lasted for thirty-two years.

I

Men who live alongside animals learn a lot about their health and eating habits. At the end of the 1953 tests, when the Utah sheep were trailed off the winter range to their lambing pens near Cedar City, it was obvious to the ranchers that something out of the ordinary had happened. The wool of some of the sheep sloughed off in clumps; most of the adult sheep had unusual blisters and sores around

their eyes, cheeks and lips; and the new lambs were either born dead in a stunted condition or were so weak they were unable to nurse and quickly died. The malady claimed its victims with dispatch: within a few days 2,000 ewes and 2,200 lambs were dead. Kern Bulloch, a herdsmen, recalled the scene of carnage at the lambing pens:

> "When they started to lamb...the lambs were born with little legs, kind of pot-bellied. As I remember, some of them didn't have any wool, kind of a skin instead of wool...And we started losing so many lambs that my father...just about went crazy. He had never seen anything like it before. Neither had I; neither had anybody else."

From the outset, the sheepmen were at the mercy of the atomic scientists. Some had been within forty miles of ground zero during the tests, and their long experience with sheep on this winter range told them that there had to be a connection between the shocking dieoff and the Nevada tests. But they had not been warned of any dangers, and they knew nothing about the effect fallout might have on their health or on that of their animals.

The scientists who were running the tests at the proving ground were certainly aware that the herdsmen and their sheep were at risk. They not only knew thousands of sheep were grazing in the downwind area where they were "throwing" the fallout, but commonsense surely informed them that the fission products generated by their tests were blanketing this desert feeding ground with a fine, deadly dust composed of a 200 different radioactive isotopes of 35 elements.

When news of the sheep dieoff reached Washington, the AEC sent a hand-picked team of experts to Cedar City to conduct an investigation. It was headed by Dr. Paul Pearson of the Division of Biology and Medicine, and it included two veterinarians, R.E. Thompsett of Los Alamos and Col. Robert Veenstra of the Marine Corps, who had won the confidence of AEC officials by previous radiation work they had performed for the Commission.

The sheepmen were confused by the conflicting signals they received from Pearson and his experts as they questioned the herdsmen and used radiation detection equipment to examine some of the dead sheep. Spontaneous comments of the veterinarians and their descriptions of animals that were "hotter than a $2 pistol" gave the owners reasons to assume that the experts were convinced that fallout was a cause of the sheep slaughter. But as the days went by, that impression was shattered as Pearson and his aides began throwing out comments designed to extinguish the ranchers' expectations that the government would assume financial responsibility for their losses.

This hardball campaign included assertions that the animals had suffered from serious malnutrition and that scientific studies would have to be carried out at the AEC's laboratories to determine whether radiation was implicated in the deaths of the ewes and lambs. Inital intimations of sympathy were replaced by tough talk. When Doug Clark, a rancher who was an elected County Commissioner, raised doubts about the AEC's explanations at a public meeting, an Army Colonel called him a "dumb sheepman" and gave him a tongue-lashing that may have triggered Clark's fatal heart attack two hours later.

The campaign to dampen contemplation of legal action by the owners was intensified by blunt messages delivered in private conversations by Pearson and by Joe Sanders, a deputy manager of the test site. In a confidential chat with rancher Joe Pace, Sanders blurted out, "Joe, the easiest thing we could do would be to pay for these sheep, but if we paid for them, every woman that got pregnant and every woman that didn't would sue us." And Paul Pearson was even more specific when he advised Steve Brower, the young County Agent (a fellow Mormon who he perceived as a neutral party), that the AEC had an official policy and that "under no circumstances could [it] allow the precedent to be established in court that the AEC was liable for radiation damages, either to animals or humans."

The slaughter of the sheep loomed as a serious obstacle to further testing in Nevada, so when the Cedar City investigation was closed, the AEC put its ace damage-control expert, Dr. Gordon Dunning, in charge of "resolving" the issue. Trained in mathematics, Dunning's official assignment in the Biology and Medicine division was to safeguard public health and safety. In reality, however, he spent most of his time protecting the AEC from flames of criticism -- and his task as a "fireman" was to arrange the "facts" and control the flow of information so that the public would be believe that no individual or animal had been harmed by fallout or other radiation emanating from the AEC's activities.

Dunning, as always, did his job well -- too well. Supposedly "comparative" studies of irradiated sheep by AEC veterenarians at Los Alamos and Hanford were initiated, and given a SECRET classification. He supervised the production of official fallout maps that were

falsified to minimize the menace to future testing posed by the Upshot-Knothole tests. And by October he was in a position to make a Machiavellian representation to his superiors that he had succeeded in persuading the veterinarians to sign a concensus statement ruling out fallout as a factor in the decimation of the Utah sheep herds, although in truth there was no consensus and the signatures he "obtained" were appended to an attendance-sheet. Subsequently Dunning guided the preparation of a Final Report issued in January 1954 in which the AEC used its own classified "scientific studies" to absolve itself of any responsibility for the death of the Utah sheep.

When the AEC's experts returned to Cedar City after an absence of seven months to present the "scientific" conclusions in their Final Report to the "dumb sheepmen," they had every reason to believe that they were drawing a final, impenetrable curtain on this episode. The whole situation declared that the sheep owners' cause was hopeless: the government had a monopoly on radiation knowledge, and there were no scientists who would help thhe sheepmen present a credible case in court.

But there would be more Acts to this public drama. Dunning and his colleagues had misjudged their adversaries. These sheepmen were a stubborn breed, angry that a government they trusted had betrayed them. Whatever the odds, they would fight on, sustained by the belief that in the end the government would compensate them for the losses it had inflicted on them.

A few months later they persuaded a country lawyer, Dan Bushnell, to take their case. Bushnell was an aggressive young attorney who shared their stubbornness and their faith that, somehow,

decency and fair play would prevail. Bushnell had no way of knowing that he was embarking on a quixotic quest for justice that would last for over three decades and add a lurid footnote to American jurisprudence before the Supreme Court of the United States would end his odyssey by turning a blind eye to his final, fascinating appeal in 1986.

When he filed the Bulloch case in federal court in Salt Lake City in 1955, Bushnell knew he was a barehanded David challenging a government Goliath with unlimited resources, but he thought the facts overwhelmingly favored his clients and he assumed that at least one of the veterinarians would stick by his original diagnosis and testify that fallout was implicated in the demise of the sheep. He also assumed that the government's lawyers would be ethical, and felt that when they discovered that some of the AEC's experts believed radiation contributed to the death of the animals they would arrange a quiet, out-of-court settlement covering the $225,000 market value of the sheep.

For Dan Bushnell, the Bulloch case became a graveyard of misbegotten assumptions. He got one break at the outset when A. Sherman Christensen, a sensitive, upright jurist who knew rudimentary things about sheep and had a reputation for scrupulously interpreting the law, was assigned to preside over his case. But that was thhe only advantage that fell his way. His subsequent efforts to extract crucial facts from the government's attorneys were frustrated; and his plan to use Thompsett, Veenstra and Holmes to establish prima facie proof that fallout was

cause of the sickness that killed the sheep ended in a cul-de-sac when these witnesses were uncooperative or evasive.

At the trial, Bushnell had no trouble proving the damages his clients had suffered or demonstrating that the operators of the test site failed to warn the sheepmen of the dangers they faced from the fallout, but he also had to prove that radiation was one of the causes of the sheep slaughter, and this was a hurdle he could not surmount. To his dismay, the three veterinarians who originally diagnosed radiation damage either disavowed their initial opinions or took the stance that they were not qualified to express professional opinions about radiation harm to animals.

The battery of government lawyers knew, of course, that Bushnell could not win his case unless he could convince the judge that fallout had been a factor in the death of the sheep. As a consequence, they adopted the strategy of surrounding Bushnell with fallout "facts" which would demonstrate conclusively that the atomic dust dropped in the downwind area consisted of "low-level" radiation that was harmless. This generated a call for Gordon Dunning's talents, and by juggling the meagre information that was available, Dunning produced fallout maps and other data that fit the needs of the defense lawyers. Armed with this "scientific" information, the lawyers for the AEC overwhelmed the court by presenting a phalanx of twenty of the "best informed experts"* in the country who gave identical, unswerving testimony that (as Judge Christensen noted in his 1956 opinion) "the maximum amount of radioactive fallout in any area in which the sheep could have been, would have caused no damage."

[* The text will contain a footnote which lists the names of the twenty experts.]

Sherman Christensen sat as both the judge and the jury in Bulloch, and his flat, final conclusions told Bushnell it was folly to appeal his judgment to a higher court. The AEC had closed the door again -- and this time secured it with twenty bolts provided by hand-picked experts who, it declared, were "best in a position to know." But this case would have more lives than one, and it would return in a new and sordid guise to Judge Christensen's court twenty-three years later afte Congressional committees uncovered truths that would would shear these bolts and unlock this door.

III

When Sherman Christensen's legal opinion was embalmed in a book of law in 1956 it had all of the adornments of finality. The odds were at least one-million to one that the sheep case would ever be disinterred. But in the winter of 1979 it was resurrected by a national furor over fallout that focused, in part, on the radioactive debris that fell during the Upshot-Knothole tests. This development involved anguished allegations by ex-soldiers and downwind civilians that exposures they received afflicted them with cancers.

A public outcry began with demands for veterans benefits by men who had been sent to Nevada to take part in mock battlefield maneuvers near to ground zero immediately after certain bombs were detonated. The claims of the "atomic soldiers" were escalated into a gripping national news story when a University of Utah epidemiologist, Dr. Joseph Lyon, published a survey in the New England Journal of

Medicine which identified an epidemic of leukemia among civilians who lived in southern Utah during the atmospheric tests.

These developments brought demands that pertinent files be declassified, and in short order congressional investigators were brandishing documents from the archives of the Department of Justice, the Public Health Service, and the Atomic Energy Commission which revealed the evasions and falsehoods the government had used to mask the radiation harm it had inflicted on it's citizens. Dan Bushnell was appalled by what he learned as a spectator at a joint hearing held in Salt Lake City by a House and a Senate subcommittee. Now a professor in the Graduate School of Management at Brigham Young University, an older and warier Steve Brower recalled the deceptions Paul Pearson and his aides used in 1953 to bamboozle the sheepmen and to conceal incriminating evidence. After reviewing the old files, the director of the National Institutes of Health, Dr. Donald Frederickson, informed the Congressmen that "it would have been extremely difficult, probably impossible, to conclude that radiation did not at least contribute to the cause of death of the sheep." And the General Counsel to the Department of Health Education and Welfare, Peter Libassi, testified that in 1953 AEC officials suppressed dissenting opinions of PHS experts who had examined the Utah sheep.

But it was an extraordinary report filed later with the Congress by the House Subcommittee on Oversight and Investigations which convinced Bushnell that his opponents had committed a fraud on the court and told him he had to file a seldom used motion for a new trial in an effort to persuade Judge Christensen to re-open the Bulloch case. The Subcommittee's unanimous report, "The Forgotten

Guinea Pigs," contained a series of shocking accusations. It expressed a blunt opinion that federal officials had "knowingly disregarded and suppressed evidence correlating the deaths of the sheep to radioactive fallout"; it drew a conclusion that Upshot-Knothole fallout was "more likely than not, the cause of the 1953 sheep deaths"; and it found that the government had "wrongly denied compensation to the sheep ranchers" for their losses.

Bushnell got additional encouragement from a 620-page analysis apppended to the House report which explained how the sheep probably died. That study was prepared by Dr. Harold Knapp, a fallout specialist who had briefly worked for the AEC in the 1960's. Knapp had caused consternation at the AEC in 1962 when he discovered that the agency was ignoring the massive doses of internal radiation delivered to infants and adults who drank contaminated milk marketed by downwind dairies. Harold Knapp's stubborn adherence to this unwanted truth made him a persona non grata at the AEC. However, his work won the respect of many scientists, and although he was then working at the Pentagon as a director of a program to build a survivable nuclear-war communications system, Knapp responded when the House subcommittee requested that he use his expertise to evaluate the sheep deaths.

Dr. Knapp accomplished this task by devoting virtually all of his spare time over a period of fifteen months to a study of the 1953 "facts" and the new data in the declassified documents. His analysis bolstered Bushnell's resolve, for he developed evidence that sheep were "vacuum cleaners for fallout" and he concluded that in areas where the external dose of radiation was 3 or 4 rads, the sheep

were getting up to 35,000 rad doses to their thyroids and lethal 3,000 to 12,000 rad doses to their gastrointestinal tracts. Knapp, functioning as a scientific detective, also exposed the techniques Gordon Dunning used to obscure obvious truths, and spotlighted the strategem Dunning had devised to fabricate a unanimous "agreement" by the veterinarians exonerating the AEC from any responsibility for the demise of the sheep.

(There will be, in a box, a photograph and a terse profile of Dr. Knapp.)

IV

It is a difficult assignment under American law to seek a new trial by offering newly-discovered evidence to a judge. Once adversaries have had their day in court, our legal system has a strong bias in favor of repose and against re-opening decisions made with open solemnity.

It is much more daunting to request a new trial after the elapse of a quarter of a century on the ground that an adversary dishonestly vitiated the very process by which justice is administered. To establish facts that would catch the conscience of a judge, as Dan Bushnell fully realized, would entail uncontrovertable proof that lawyers had engaged in unethical conduct, or crucial documents had been concealed, or that persons had connived to alter the testimony of vital witnesses. The motion Bushnell lodged with Judge Sherman Christensen in the winter of 1982, and the evidence he adduced at a four-day trial the next May, encompassed all of these manifestations of misconduct, and more.

The 56-page opinion Judge Christensen published a few months later is a landmark of American law, for it describes a monstrous miscarriage of justice. No other jurist this century has adjudged, twenty-six years after his initial decision, that high-level federal lawyers abetted by high-level employees of federal agencies perpetrated a fraud on a federal court.

Impelled by clear and convincing evidence of misconduct, Judge Christensen based his order granting the sheepmen a new trial on four explicit findings of fact. He concluded that a fraud had been perpetrated on his court by Paul Pearson and others who concealed a Hanford experiment involving irradiated fetal lambs that produced "signs and conditions almost identical" with those exhibited by the Utah sheep. He found that Pearson, Dr. Bernard Trum, a veterinarian employed at the AEC's Oak Ridge laboratory, and the government's lawyers undermined the process of justice through a sustained campaign of "deceitful conduct" that intimidated Veenstra, Thompsett and Holmes to alter their professional opinions about the impact of the fallout on the ewes and lambs. Judge Christensen also determined that Pearson, Dunning and their aides misled him by juggling the radiation maps the AEC prepared for the trial in order to eliminate evidence of downwind hot spots and to minimize the doses delivered to the sheep. And with obvious reluctance (for he had expressely rejected as "unthinkable" Bushnell's cover-up contentions at the original trial), Christensen found that the lawyers representing the AEC (Don Fowler, Charles Eason, John J. Finn, Lewellyn Thomas, and Chalmers King) circumvented the law and breached ethical duties owed to the court by

filing, under oath, "highly deceptive" answers to crucial interrogatories directed to them by the plaintiffs.

Sherman Christensen's forceful opinion, written more in sorrow than in anger, granted a new trial to the owners of the dead sheep. And Dan Bushnell (knowing that the government had only a remote chance of winning an appeal) assumed that chastened federal officials would enter into negotiations and work out a compromise settlement. But once again the case of the irradiated sheep defied all ordinary logic.

V

In what one legal scholar has described as an "inexplicable outcome," the United States Court of Appeals for the Tenth Circuit reversed Judge Christensen. This result is difficult to explain because appellate court's in this country almost never overrule a trial judge who grants a new trial if his/her decision is "permissible in light of the evidence." What makes the Tenth Circuit's Bulloch decision a candidate for a Legal Hall of Infamous Opinions is that it marked the first time in it's history that that Court overturned a decision by a trial judge to award a new trial. The restraint appellate courts have religiously exercised in declining to interfere with new-trial determinations by trial judges is manifest by the circumstance that in this century the United States Supreme Court has never intervened in a case where a trial court granted a new trial.

Many students of legal ethics and appellate practice have been perplexed by the unjudicial approach the Bulloch majority used to formulate its decision. Indeed, the anomolous outcome of this case

has raised a nagging question whether the judge who wrote the Bulloch opinion should not have disqualified himself. Before he was appointed to the U.S. Court of Appeals in 1962, this jurist was a member of a prominent Santa Fe law firm that performed legal work for the Los Alamos National Laboratory and, at a personal level, was a social friend of many of the patriots who managed that institution.

THE APPARAT AND THE URANIUM MINERS

"The tragedy [of the uranium miners]
was totally avoidable."
-- Merril Eisenbud
AEC Industrial Hygienist

When the Atomic Energy Commission came into existence on January 1, 1947, the United States was importing all of its uranium from the Belgian Congo and Canada. As an extension of General Groves' strategy to corner the world uranium market, the law that established the AEC contained a provision that awarded it ownership and exclusive control over all deposits of this strategic mineral, and the Commission promptly created a Division of Raw Materials to develop a uranium mining industry in this country.

Raw Materials soon had a team of several hundred geologists combing the Colorado Plateau for outcrops of uranium and conducting drilling to locate ore bodies that would be productive uranium mines. This emergency prospecting was a huge success and, in response to bonuses and guaranteed prices offered by the AEC, large and small mining companies were soon gouging the government's ore out of the earth at locations in Utah, in western Colorado and on the Navajo Indian Reservation in Arizona.

The health hazards of uranium mining were identified with clarity for the AEC in the spring of 1948 when Dr. Bertram Wolfe and Merril Eisenbud traveled from the Commission's new Health and Safety Laboratory (HASL) in New York City to study radiation problems at the uranium mines and mills that were commencing operations in western Colorado under the aegis of the AEC. Eisenbud, who would later found New York City's first office of environmental protection in the 1960's, came to Colorado from an industrial health triumph in Ohio that had put a bright safety feather in the cap of the AEC by devising a system of controls that virtually eliminated beryllium disease in the world.

The AEC needed the metal beryllium as a reflector for highflux reactors, but beryllium processing plants in Ohio had allowed this toxic substance to pervade the surrounding environment and produce a lethal epidemic of lung disease in their communities. HASL dispatched Eisenbud to tackle this problem and he organized an emergency medical survey that readily identified the cause of this epidemic.

Knowing lives were at stake, Merril Eisenbud fixed exposure limits that would protect the workers and the general community and then persuaded AEC officials to incorporate the safety standards he had designed into the AEC's procurement contracts with the beryllium producers. Eisenbud secured the approval of this enforcement mechanism even though his agency was not the sole purchaser of this

metal (it was used by the industry that manufactures fluorescent lights) and despite the fact that compliance would increase the price the government would have to pay for the end product. The AEC was under no lugal obligation to regulate the production of beryllium by its contractors. It acted in this instance in response to Merril Eisenbud's argument that his agency had a moral duty to conduct its activites in a manner that would minimize hazards to the lives or the health of the workers who were part of the atomic age's new chain of production.

Experience prior to World War II had taught industrial hygienists in this country to use conservative criteria in setting safety standards for industries whose employees were exposed to hazardous materials in their workplaces. It was considered "good practice" to make an initial judgment about "allowable" exposures, and then to apply a "safety factor" and fix a performance standard five or ten times below that level. (General Groves provided an example of this technique in his autobiography when he noted with pride that all of the workers in the war plants of the Manhattan Project were protected from radiation dangers by "a large factor of safety.")

Wolfe and Eisenbud had studied the deadly consequences of uranium mining in Europe, and the unventilated mines they inspected on their Colorado trip filled them with forebodings. The report they wrote a few weeks later proposed that the allowable radon contamination

in uranium mines be the same as the initial standard fixed for U.S. workers handling radiation products in 1941 by the newly-organized National Commission on Radiation Protection (NCRP). They also recommended that the AEC's ore-procurement contracts with the mining companies contain an enforcement mechanism that would compel them to adhere to this standard.

Two shocking developments greeted Wolfe's and Eisenbud's initiatives. The first was a report from the National Bureau of Standards analyzing the samples of radon they had gathered during their Colorado tour. Some samples revealed concentrations of radon 500 times higher than the exposures allowed by the NCRP. The second shock came in the form of a furtive call to Dr. Wolfe from an AEC official in Washington ordering HASL to "keep away from" the uranium mining problem. Secrecy has cloaked the deliberations that produced this decision, but in 1980 an NBC reporter extracted an admission from Jesse Johnson, the head of Raw Materials, that this order came from one of the five commissioners.

This decision was a milestone, for it marked the birth of a secrecy-is-more-important-than-safety policy that encouraged the AEC to sacrifice the lives of innocent civilians on the alter of national security. The outlook that caused Chairman David Lilienthal and the first members of the AEC to turn their backs on the uranium miners who were producing the source materials for atomic bombs is

baffling. There was no conflict between the needs of worker safety and the requirements of national security: U.S. uranium production was miniscule in 1948, and it would not have been disruptive to suspend mining for a few weeks and develop safety regulations comparable to the guidelines Eisenbud had developed earlier for the beryllium industry.

The AEC's decision to ignore the peril confronting the uranium miners was so cavalier that Merrill Eisenbud was still appalled thirty-one years later when he explained to a congressional committee how easy it would have been to design and implement a program to expel radon from all uranium mines. In 1948, the world's foremost experts on radiation safety either worked for the Commission or for health agencies of the federal government. The AEC had a corps of health physicists inherited from the Manhattan Project who had fashioned pioneering programs to protect workers in the plants that were processing fissionable materials. The Commissioners had persuaded the distinguished radiologist, Dr. Shields Warren, to guide their new Division of Biology and Medicine. Advice was available from the National Cancer Institute, which had just hired Dr. W.H. Hueper, an expert with international credentials, to establish a new Center of Environmental Health. And valuable insights could have been provided by USPHS industrial hygienists such as Henry Doyle and Duncan Holaday who were familiar with the ventilating devices used

by U.S. mining companies to eliminate toxic contaminants from their mines.

Merrill Eisenbud has steadfastly believed that if the AEC had assembled a team of experts to tackle this problem in the summer of 1943, it would not have been difficult to quantify the radiation hazards and formulate a safety regimen to protect the miners. History supports Eisenbud's judgment, for the first air samples taken in U.S. mines revealed astronomical radon concentrations that cried out for immediate action. Such evidence would undoubtedly have produced a swift conconsus that an epidemic of lung cancer would afflict the miners unless their mines were ventilated. Such an assessment would likewise have produced conclusions that life-saving ventilation could be provided for a few pennies per pound of uranium, that the states where deposits of ore were being found (Colorado, Utah, Arizona and New Mexico) were totally unprepared to deal with the problem, and that the AEC had the power to compel the mining companies to ventilate their mines either by writing a safety standard into its ore-procurement contracts -- or by requesting that the Department of Labor use its broad authority under the Walsh-Healey Act to fix and enforce such a standard.

Medical history tells us that any team of experts also would have readily reached a consensus about the health effects if U.S. miners worked for even a few weeks in mines saturated with radon gas. In 1948 there was little dispute

about the cancer risks facing industrial workers who were exposed to high levels of radon. Every industrial hygienist who read the initial air samples taken in U.S. mines was appalled. Moreover, two of the most widely known 20th century studies of occupational diseases involved cancer epidemics caused by the inhalation of radon. Presented as case studies in every medical school, these textbook tragedies involved a European study of Czechoslovakian uranium miners and a famous study of U.S. workers who painted radium on the dials of clocks and watches.

The post-mortems written about these cases occupied a special niche in medical literature, and underscored two conclusions about the manner in which the cancers induced by radon gas and its insidious, long-lived "daughter" by-products would manifest themselves. One finding was that the initial damage could not be detected by physicians. Another finding indicated that there would be a latency period of at least twelve years before lung cancers appeared and claimed their first victims.

It was these medical realities, and awareness that it would be economical to ventilate all U.S. uranium mines, that appalled Merrill Eisenbud in 1948 and impelled him to tell a congressional hearing in 1979 that the uranium miner tragedy had been "totally avoidable." It had been avoidable, he meant, if the Atomic Energy Commission, the sole purchaser of the output of the mines, had been willing to

provide the kind of leadership it had exerted in conquering beryllium [redacted] in Ohio.

Eisenbud's opinion was echoed in 1979 by Duncan Holaday, a PHS field hygienist who had spent twenty frustrating years on the Colorado Plateu trying to wring action from the states and the mining companies to protect the uranium miners. From the moment he scrutinized air samples which revealed that many miners were breathing levels of radon over 500 times higher than permitted in U.S. industrial plants, Holaday viewed the AEC's abdication as unconscionable. But, like so many of his colleagues in the Public Health Service, he was intimidated the AEC's inordinate power and the mantle it wore as the paramount defender of the nation's security.

The myths and outright lies the AEC used to duck the duties it owed to its uranium miners foreshadowed the indifference it exhibited later toward the civilians whose lives and health were imperiled by it bombmaking activities. The Commission began what became a nation-wide coverup by treating the mission and the message of Wolfe and Eisenbud as a non-event, and by adopting the pose that there was no medical evidence that uranium mining was hazardous. Ignoring the excellent safety criteria developed during the Manhattan Project by their own hygienists, AEC officials passed the buck by taking the stance that it would be premature to draw conclusions about radon dangers in U.S. mines -- or intrude on the mine safety functions of the

states -- until after the completion of a decade-long deathwatch study which was being conducted by the Public Health Service.

Of all the civilian tragedies spawned by the AEC's gross neglect of the radiation safety duties imposed upon it by Congress, the most poignant involved 200 Navajo Indians who worked in some of the first uranium mines in the United States. These Indians were living pastoral lives in the remote, redrock country west of Shiprock, New Mexico when the AEC began its campaign to develop domestic supplies of uranium. A cruel irony hovers over their story, for the homeland environment of these Navajo's was so clean, and their lifestyle was so simple, that physicians who practiced medicine on their reservation in the 1950's observed a curious absence of certain kinds of cancer among these Indians.

These Navajo uranium miners were doomed the moment the search for U.S. uranium began. They were doomed because their Reservation contained rich deposits of uranium located near the surface of the earth. The were doomed because their nation needed these ores and its Atomic Energy Commission was inclined to sacrifice lives to expedite the output of uranium. They were doomed because the long years it would take for the radiation that lodged in their lungs and bones to generate an epidemic of lung cancer would allow the AEC apparat to pretend their health was not imperiled. They were doomed because their inability to communicate in

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and the federal health officials who appeared from time to time to ask them questions and give them physical examinations.

These Navajo miners and their families were doomed to bear all the burdens of the lung diseases that devastated their lives because they did not comprehend what had happenead -- and nobody informed the widows that they were entitled to death payments under the worker's compensation laws of the states in which they worked. And they were doomed because, contrary to the myth of states-responsiblity the AEC brandished as its shield for nearly two decades, state safety officers had no authority to enter the Navajo Reservation or to compel the companies mining Indian ores to ventilate their mines.

All of the uranium miners on the Colorado Plateau were victims of the AEC's abdication. If the life-saving safety program Merrill Eisenbud envisioned in 1948 had been carried out, the workers would have known what steps to take to protect themselves: miners and mine foremen educated about radon risks would have understood the dangers of dead air and would have arranged the air vents so that fresh air was blowing in the stopes where radon-emitting ores were being blasted from the earth and in the tunnels where they performed their daily duties.

In 1948, the AEC knew the risks and had the funds and the know-how to mount a program of prevention that would have saved the lives of hundreds of uranium miners. Thus,

its decision to disavow its paramount responsibilities and dump the problem on the doorstep of states that were not prepared to deal with it was tantamount to a death sentence for the miners. The outcome was an avoidable industrial tragedy which converted them, unwittingly, into medical freaks whose bodies absorbed world-record amounts of radiation.

Although the physicians who headed the AEC's Division of Biology and Medicine (DBM) maintained for many years that there was no evidence that the health of U.S. miners had been endangered, research projects they supported gave the lie to their public protestations. The knowledge, for example, that many of the miners were carrying heavy burdens of radiation in their bodies tempted DBM doctors to regard them as guinea pigs who could enlarge medical knowledge concerning the impacts of radiation on human health.

This outlook made the uranium miners the subjects of two notable medical experiments. The first, commenced in 1954, was an AEC-financed epidemiological study of all uranium miners on the Colorado Plateau wherein a medical caravan meandered across four states conducting physical examinations and gathering work-history information that could be correlated later with radiation readings taken in specific mines. This documention enabled federal health officials to track the life and death of each miner and accumulate clinical data for modern medicine about the

cancers induced by differing exposures to radon and radon-daughters.

The second study, designed by DBM's Dr. Bernard Nebel, involved microscopic analyses by physician-researchers of samples of radiation-impregnated lung, bone and muscle taken from living and dead miners.who had worked in underground mines for five or more years. Nebel's plan entailed a process whereby physicians on the Plateau who performed autopsies "sectioned" the lungs of dead miners with a ham slicer. These specimens were then pickled and mailed to laboratories where specialists used sophisticated radiographic equipment to measure the damage done to human tissue by invasions of radiation. This experiment caused one of Nebel's queasy colleagues to fear "traumatic" reactions from the widows of deceased miners, so it was conducted in secret.

The clandestine nature of this wide-ranging experiment raises vexing questions concerning the DBM's view of the ethical duties of physicians in the 1950's. Since the working miners were never given information about the hazards they were encountering or about the radiation their bodies had absorbed, it is doubtful that the families of the victims gave authentic "informed consent" for these experiments as required by the canons of medical ethics.

Documents from that period make it evident that AEC officials were pursuing a policy that elevated the production of domestic uranium above preservation of human

life and health. In the summer of 1951, for example, a DBM researcher, Dr. William F. Bale, took a reading in a Utah mine that had an astronomical concentration of radon 4,400 times greater than the exposure then allowed in the nation's radium dial painting industry. Bale not only took no action to protect the miners, but a few days later he include this compliment in the report he filed with his superiors: "They (USPHS) seem to have conducted their work so far without unduly alarming miners as to the hidden hazards that may exist, or in any way impeding mining operations."

The AEC's successful campaign to not alarm the miners -- and to avoid creating problems for the mining companies who were helping them exceed their production targets -- required vigilant action by officials in the AEC hierarchy. Dr. Shields Warren fired one of the first shots in this surveillance effort in 1943 when he killed a federal study of uranium mines and miners that would most certainly have alarmed the miners and generated front page stories in the nation's newspapers. The plan for this survey by the new National Cancer Institute (NCI) was prepared by Dr. Hueper, an outspoken Austrian emigre who had studied the gruesome facts about the European uranium miners. Warren had spotted Hueper as a potential truth-telling whistleblower, and later, when the Austrian was about to present a paper to a medical conference in Denver that recited blunt statistics about the incidence of lung cancer among the European miners, Shields Warren intervened, had

his speech censored, obtained an order forbidding him to travel west of the Mississippi River, and subsequently tried to persuade the director of the NCI to fire Hueper.

The AEC's power to intimidate public health officials grew out of steps it took in the 1940's to classify all information about uranium production as SECRET and to require non-AEC personnel to obtain Q-clearances. These maneuvers allowed the apparat to assert Big Brother dominance over the health professionals and enabled it to set up a system of surveillance and censorship to control the reports and press releases issued by the Public Health Service. Such stage-managing meant that the tragedy of the uranium miners would be acted out in a darkened theatre of shadows, lies, and illusions where there were no clear lines of authority and where the Atomic Energy Commission could pretend that it was doing everything in its power to protect the health of its uranium miners.

The most lethal of these lies was the canard that it was premature to draw conclusions about radiation hazards in U.S. mines until the PHS epidemiologists reported there were sufficient deaths to demonstrate that there was a lung cancer epidemic on the Colorado Plateau. Another was the ever-present refrain that the AEC, like a good neighbor, was doing its best to help the states and the mining companies come to grips with <u>their</u> mine safety problems. And then there was the hoax that it was impossible to set federal exposure standards until the PHS studies produced the

baseline data federal radiation experts needed to formulate such regulations. And, finally, there was the last-refuge argument (presented unblushingly by the government at the 1983 trial of a lawsuit brought against the AEC by a group of Navajo widows) that the lung cancers of miners were either caused by cigarette smoking or by "sandy soils around their homes."

All of these contentions were, of course, both unscientific and untrue. But these deceptions were accepted by the American people because the Atomic Energy Commission was perceived as a citadel of national security and, for a season, its assertions about radiation facts had the effect of law. In the end, time and truth would overtake the AEC's fictions and curtail its predominance over atomic age issues to a half-life of slightly more than twenty years. But that would be ample time for its activities to poison environments and to inflict additional tragedies on other, unsuspecting Americans.

EXHIBIT C

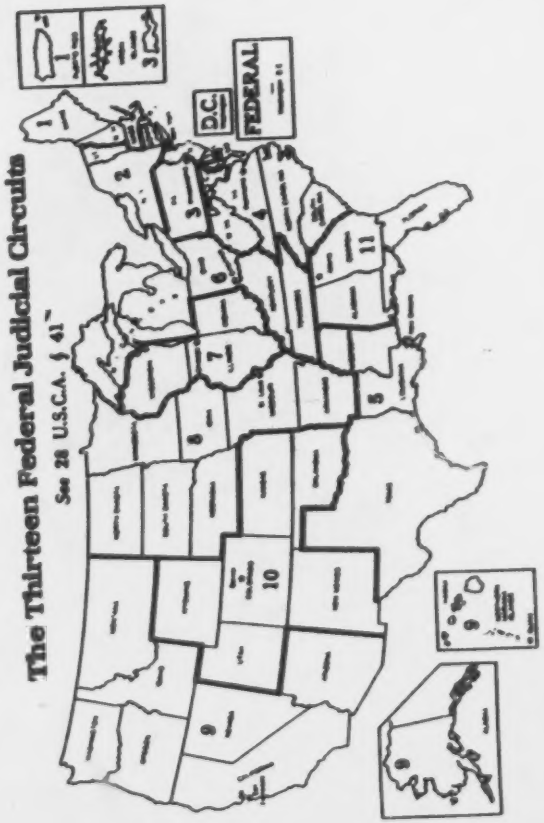

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Exhibit C

that they used due diligence in trying to uncover the facts. *Cowerly v. Westinghouse Electric Corp.*, 622 F.2d 117, 120 (9th Cir.1980); *Rutledge*, 576 F.2d at 250. Appellees' silence or passive conduct does not constitute fraudulent concealment. *Rutledge*, 576 F.2d at 250. Further, appellants' mere ignorance of the cause of action does not, in itself, toll the statute. *Campbell*, 676 F.2d at 1127.

[21] the doctrine of fraudulent concealment does not toll the statute of limitations in the case at bar. Appellants do not present any facts indicating an affirmative effort on the part of any appellee to mislead them or to conceal the fraud. The general partner did fail to disclose certain geological reports known to him and the Jackson appellees prior to 1979, but appellants do not indicate that these appellees took affirmative steps to mislead appellants. Rather, appellees passively concealed the reports by not disclosing them to the investors. In such situations, the fraudulent tolling doctrine does not apply. Appellants cannot translate their lack of due diligence into active concealment by appellees.

[22] Appellants Rather, Poulsen, Donahue, and Anderson require separate consideration, although they too are precluded from relying on the doctrine of fraudulent concealment to toll the statute. The Davidson brothers told these appellants not to worry about the 1978 annual report. One broker told Poulsen that Intervest would provide substitute properties. Yet, these individuals had received the annual report which gave them constructive notice of their claims and explicitly stated that Intervest could not provide substitute properties. Additionally, appellants failed to use due diligence in their investigation of these claims. Once appellants had clear knowledge of their claims, it was not reasonable for them to rely on reassuring comments from a broker. *See Hupp v. Gray*, 500 F.2d 993, 997 (7th Cir.1974).

[23] Appellants allege that the Jackson appellees organized sham corporations to execute the scheme to defraud them. Even if appellants supplemented the record with a factual basis for this claim, there is no indication that Jackson organized these corporations to conceal the fraud. Rather, they are, as alleged, a means for the execution of the fraud.

III.

THE DISTRICT COURT'S DECISION TO STAY DISCOVERY

[24, 25] The district court should permit discovery if it appears from the affidavits filed that the party opposing the summary judgment motion could not, for reasons stated, present facts essential to justify his opposition. Fed.R.Civ.P. 56(f). Courts will deny Rule 56(f) discovery applications where the moving party's evidence affirmatively negates the factual issues which the opposing party claims remain controverted. *See Emco Corp. v. Federal Trade Comm'n*, 603 F.2d 120 (D.C.Cir.1980); *Schlesinger v. Central Intelligence Agency*, 591 F.Supp. 60, 64-65 (D.D.C.1984). A party may not forestall an unfavorable ruling on a summary judgment motion merely by alleging fraudulent and/or conspiratorial conduct. The burden is on the party seeking to conduct additional discovery to put forth sufficient facts to show that the evidence sought exists. *VISA International Service Association v. Bankcard Holders of America*, 784 F.2d 1472, 1475 (9th Cir.1986) (courts deny Rule 56(f) applications where it is clear that the evidence sought is almost certainly nonexistent or is the object of pure speculation).

The evidence submitted overwhelmingly indicated that appellants had notice of the fraud on the date they received the 1978 annual report. Additional discovery could not reveal facts indicating appellants had less knowledge than they admittedly had. Even as to the issue of fraudulent concealment, appellants had sufficient notice of their claim such that they could not present evidence of reassurances from appellees negating that knowledge.

[26] A district court "has wide latitude in controlling discovery, and its rulings will not be overturned in the absence of a clear abuse of discretion." *Foster v. Arcata Associates, Inc.*, 772 F.2d 1453, 1467 (9th Cir. 1985), *cert. denied*, — U.S. —, 106 S.Ct. 1207, 89 L.Ed.2d 576 (1986). The reviewing court applies the abuse of discretion standard in reviewing a district court's decision denying an application to continue a ruling on a summary judgment motion to permit discovery. *Id.* Here, there was no abuse of the district court's discretion in staying discovery.

IV.

STANDARD OF REVIEW

This Court reviews *de novo* a trial court's grant of summary judgment. *Lopish v. Thomas*, 716 F.2d 675, 677 (9th Cir. 1983). Summary judgment is appropriate if, in viewing the evidence most favorable to the opposing party, there is no genuine issue of material fact and the substantive law was correctly applied. Fed.R.Civ.P. 56(c); *Roberts v. Continental Insurance Co.*, 770 F.2d 952, 955 (9th Cir.1985).

[27, 28] Ordinarily, a defendant has an extremely difficult burden to show that a fraud action is barred as a matter of law. The determination of whether a plaintiff knew or should have known of a cause of action presents a question for the trier of fact. *Seaboard*, 677 F.2d at 1389-10. However, the extent to which a plaintiff used reasonable diligence is tested by an objective standard. *Krowne v. Security Gas & Oil, Inc.*, 572 F.2d 768, 770 (9th Cir.), *cert. denied*, 459 U.S. 1035, 103 S.Ct. 444, 74 L.Ed.2d 600 (1982). A district court may, therefore, grant a summary judgment motion if the uncontroverted evidence irrefutably demonstrates that a plaintiff discovered or should have discovered the fraud but failed to file a timely complaint. *Id.* This Court has upheld many lower court decisions granting summary judgment motions when, as a matter of law, a plaintiff knew or should have known of his injuries and failed to protect his rights in a timely fashion. *See, e.g., id.* at 770-71; *Jablon v. Dean Witter & Co.*, 614 F.2d 677, 682 (9th Cir.1980); *Winkelman v. Blyth & Co.*, 518 F.2d 590, 591 (9th Cir.), *cert. denied*, 423 U.S. 929, 96 S.Ct. 278, 46 L.Ed.2d 257 (1975).

In the present case the 1978 annual report and the general partner's September 1979 letter gave the investors sufficient notice of the fraud. These two documents informed appellants that they bought investments in coal reserves which lacked mineable coal and could not sustain a viable commercial operation.[3] They, therefore, knew or should have known that they suffered a compensable injury, i.e., that they paid more for their investment than it was worth. Thus, the district court correctly found that the statute of limitations had run as to all appellees.

The judgment of the district court is therefore AFFIRMED.

3. The district court relied only on the 1978 annual report. Because the annual report sufficiently notified appellants of their claims, the fact that two appellants did not receive the September 1979 letter does not alter the result as to them.

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Irene H. ALLEN, et al., Plaintiffs-Appellees,

v.

UNITED STATES of America, Defendant-Appellant.

No. 86-2196.

United States Court of Appeals, Tenth Circuit.

April 20, 1987.

Actions were brought against the United States under the Federal Tort Claims Act to recover for injuries and deaths allegedly resulting from radioactive fallout from open-air atomic bomb tests held in Nevada in the 1950s and 1960s. The United States District Court for the District of Utah, Bruce S. Jenkins, Chief Judge, 660 F.Supp

247, entered judgment against the Government on nine of the claims, and the United States appealed. The Court of Appeals, Logan, Circuit Judge, held that the Atomic Energy Commission, in planning and conducting its monitoring and information programs, was making policy judgments protected by the discretionary function exception despite broad congressional directives to consider public health and safety, and decisions involved in carrying out the programs at lower levels were within the exception.

Reversed and remanded.

McKay, Circuit Judge, filed a concurring opinion.

1. United States ⇐78(12)

The Atomic Energy Commission, in planning and conducting its monitoring and information programs with respect to open-air atomic bomb tests held in Nevada in the 1950s and 1960s was making the kind of policy judgments protected by the discretionary function exception to the Federal Tort Claims Act, despite broad congressional directives to consider public health and safety, and operational plans embodying the AEC policy decisions, and decisions involved in carrying out the programs at lower levels, were also within the exception, absent any act or omission of the AEC or its employees clearly contravening any specific statutory or regulatory duty or exceeding statutory or regulatory authority. 28 U.S.C.A. §§ 1346(b), 2680(a).

2. United States ⇐78(12)

It is irrelevant to issue of whether conduct of the Atomic Energy Commission and its employees with respect to open-air atomic bomb tests was within discretionary function exception of the Federal Tort Claims Act whether they were negligent in failing to adequately protect the public and whether alleged failure to warn the public was a matter of deliberate choice or mere oversight. 28 U.S.C.A. §§ 1346(b), 2680(a).

3. United States ⇐78(12)

Atomic Energy Commission policy report accepting responsibility for reimbursing radiation-caused losses could not be treated as waiving the discretionary function exception of the Federal Tort Claims Act. 28 U.S.C.A. §§ 1346(b), 2680(a).

Marc Johnston, Appellate Staff Atty., Civ. Div., Dept. of Justice (Richard E. Willard, Acting Asst. Atty. Gen., Robert S. Greenspan, Appellate Staff Atty., Civ. Div., Dept. of Justice, Brent D. Ward, U.S. Atty., Henry A. Gill, Acting Asst. Gen. Counsel, and Edward Jenn, Atty., Dept. of Energy, Ralph H. Johnson, Pamela L. Wood, and Patrick O. Cavanaugh, Trial Attys., Torts Branch, Civ. Div., Dept. of Justice, with him on the brief), Washington D.C. for defendant-appellant.

Dale Haralson of Haralson, Kimerh & Morey, Tucson, Ariz., and Ralph E. Hunsaker of O'Connor, Cavanagh, Anderson, Westover, Killingsworth & Beshears, Phoenix, Ariz. (Donovan L. Peterson of Haralson, Kimerh & Morey, David M. Bell and Scott E. Boehm of O'Connor, Cavanagh, Anderson, Westover, Killingsworth & Beshears, Stewart L. Udall of Beer and Tooze, Phoenix, Ariz., J. MacArthur Wright of Wright & Miles, St. George, Utah, with them on the brief), for plaintiffs-appellees.

Before McKAY, SETH, and LOGAN, Circuit Judges.

LOGAN, Circuit Judge.

In this action under the Federal Tort Claims Act, *see* 28 U.S.C. §§ 1346(b), 2401(b), 2671–80, nearly 1200 named plaintiffs have sued the United States, alleging some 500 deaths and injuries as a result of radioactive fallout from open-air atomic bomb tests held in Nevada in the 1950s and 1960s. The district court selected and tried twenty four "bellwether" claims, in order to find a common framework for the rest.[1] *See Allen v. United States*, 588 F.Supp. 247, 250 (D.Utah 1984). The court entered final judgment in favor of the government on fourteen of these claims and against the government on nine, leaving one claim outstanding. *Id.* at 446–47. It then granted a Fed.R.Civ.P. 54(b) motion permitting the government to appeal these claims resolved against it. On appeal the government contends that (1) the "discretionary function" exception in 28 U.S.C. § 2680(a) precludes government liability; (2) the government did not breach any duty owed to the public; (3) the government did not cause plaintiffs' injuries; and (4) the plaintiffs' claims were barred by the two-year statute of limitations in 28 U.S.C. § 2401(b). We do not discuss the last three issues, because we agree that the discretionary function exception precludes government liability.

The district court opinion states the facts fully. *See Allen*, 588 F.Supp. at 397–98, 403–50, 460–494. The authority for federal atomic bomb tests came from the Atomic Energy Act of 1946, Pub.L. No. 585, 60 Stat. 755 ("the 1946 Act"). *See* Atomic Energy Act of 1954, 42 U.S.C. §§ 2011–2296 (present version of atomic energy statutes). Under the 1946 Act, the Atomic Energy Commission (AEC) received broad discretionary power to "conduct experiments . . . in the military application of atomic energy." 1946 Act, § 6(a); *see* 42 U.S.C. § 2121(a) (same authority in present statutes).[2] The AEC was authorized to carry on such experiments "only to the extent that the express consent and direction of the President of the United States has been obtained, which consent and direction shall be obtained at least once each year." *Id.* Additionally, the AEC was "authorized and directed to make arrangements . . . for . . . the protection of health during research and production activities." 1946 Act, § 3(a). These arrangements were to "contain such provisions to protect health, to minimize danger from explosion and other hazards to life or property . . . as [the AEC] may determine." *Id.*; *see* 42 U.S.C. §§ 2012(d)–(e), 2013(d), 2061(d) (similar provisions in present statutes).

In 1950 the AEC chose an area in Nevada as a testing site. The President approved this choice. Thereafter, between 1951 and 1962, eight series of open-air tests were conducted, with the President approving each series of tests. Over one hundred atomic bombs were detonated.

Each test explosion was executed according to detailed plans which the AEC officially reviewed and adopted. Separate plans for protecting the public, and for providing the public with appropriate information, were also adopted by the AEC. To actually execute the plans, however, the AEC delegated some of its authority. The AEC selected a "Test Manager", for each test series, who had some day-to-day discretion. The Test Manager could, for example, postpone a given test because of adverse weather conditions. The Test Manager in turn delegated authority to a Radiological Safety Officer (a "Radsafe Officer") who was in charge of implementing plans to avoid radiation dangers, and a Test Information Officer who was in charge of implementing plans to provide public information on the tests. Both the Radsafe Officer and the Test Information Officer also had some day-to-day discretion in performing their duties.

At trial, as a basis for governmental liability, plaintiffs singled out the alleged failure of the government, especially of the Radsafe Officers and the Test Information Officers, to fully monitor offsite fallout exposure and to fully provide needed public information on radioactive fallout. The district court focused on these two failures in finding government liability. *Allen*, 588 F.Supp. at 372–404.

The Federal Tort Claims Act (FTCA) authorizes suits for damages against the United States

> "for injury or loss of property, or personal injury or death caused by the negligent or wrongful act or omission of any employee of the Government while act-

1. The trial lasted thirteen weeks. The trial transcript runs more than 7,000 pages, the exhibit evidence more than 54,000 pages. The district court deliberated for seventeen months, then issued an opinion which occupies 225 pages of the Federal Supplement.

2. In 1974, the AEC was abolished and its functions transferred to the Nuclear Regulatory Commission and the Energy Research and Development Administration. Energy Reorganization Act of 1974, Pub.L. No. 93-438, 88 Stat. 1233.

ing within the scope of his office or employment, under circumstances where the United States, if a private person, would be liable to the claimant in accordance with the law of the place where the act or omission occurred."

28 U.S.C. § 1346(b). In such suits, the United States is liable "in the same manner and to the same extent as a private individual under like circumstances." 28 U.S.C. § 2674. Suit is not allowed, however, for any claim

"based upon an act or omission of an employee of the Government, exercising due care, in the execution of a statute or regulation, whether or not such statute or regulation be valid, or based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty on the part of a federal agency or an employee of the Government, whether or not the discretion involved be abused."

28 U.S.C. § 2680(a) (emphasis added). The key term, "discretionary function," is not defined. For over thirty-five years the federal courts have been attempting to define it.

Plaintiffs in the present case attempted to distinguish between the discretionary initiation of government programs, at the highest levels of administration, and the decisions involved in carrying out programs, at lower levels. Plaintiffs argued that while low-level decisions may involve some "judgment," they do not fall within the discretionary function exception of § 2680(a). *See, e.g., Indian Towing Co. v. United States*, 350 U.S. 61, 64, 76 S.Ct. 122, 124, 100 L.Ed. 48 (1955) (reference to "operational level" of activity; no immunity found for government failure to operate lighthouse). The district court agreed, basing its finding of government liability squarely on a distinction between high-level and low-level government activity. *Allen*, 530 F.Supp. at 396–40.

After the district court judgment in the present case, the Supreme Court decided *United States v. S.A. Empresa de Viacao Aerea Rio Grandense (Varig Airlines)*, 467 U.S. 797, 104 S.Ct. 2755, 81 L.Ed.2d 660 (1984), in which it explicitly rejected distinctions based on the administrative level at which the challenged activity occurred. In *Varig*, various plaintiffs brought an FTCA suit against the United States, claiming that the Federal Aviation Administration (FAA) had negligently implemented plane inspection and design certification programs, allowing improper flammable materials and a defective heater system to be used to construct a specific Boeing 707 and a specific DeHavilland Dove. The planes in question caught fire and burned, killing most of those on board. The Supreme Court held, however, that the United States was immune from suit. The Court found that the contested FAA actions constituted the performance of a "discretionary function," exempt under 28 U.S.C. § 2680(a) from potential FTCA liability. 467 U.S. at 819–21, 104 S.Ct. at 2767–68.

The plaintiffs in *Varig* focused on "low-level" decisions in their suit. They challenged the actual issuance by the FAA of design approval certificates for two plane types, the decision to enforce FAA standards with a particular "spot-check" system, and the actual plane inspections that were and were not carried out under that system. 467 U.S. at 798–800, 816–20, 104 S.Ct. at 2757–59, 2765–67. The Supreme Court found that each of these actions constituted a discretionary function, immune from suit under § 2680(a):

> "[T]he 'discretionary function or duty' that cannot form a basis for suit under the Tort Claims Act includes more than the initiation of programs and activities. It also includes determinations made by executives or administrators in establishing plans, specifications or schedules of operations. Where there is room for policy judgment and decision there is discretion. It necessarily follows that acts of subordinates in carrying out the operations of government in accordance with official directions cannot be actionable.'"

Id. at 811, 104 S.Ct. at 2763 (quoting *Dalehite v. United States*, 346 U.S. 15, 35–36, 73 S.Ct. 956, 967–68, 97 L.Ed. 1427 (1953)). The Court emphasized that it is "the nature of the conduct, rather than the status of the actor, that governs whether the discretionary function exception applies in a given case." *Varig*, 467 U.S. at 813, 104 S.Ct. at 2764.

[1] On appeal, plaintiffs contend that the AEC, in planning and conducting its monitoring and information programs, was not making the kind of policy judgments protected by § 2680(a). They point to the general statutory provisions instructing the AEC to consider public health and safety, and claim that these broad congressional directives leave no further room for discretion. We disagree.

In the case before us, as in *Varig*, the government actors had a general statutory duty to promote safety; this duty was broad and discretionary. In the case before us it was left to the AEC, as in *Varig* it was left to the Secretary of Transportation and the FAA, to decide exactly *how* to protect public safety. If anything, the obligation imposed on the FAA to protect public safety was greater and the discretion granted to the FAA by Congress was less, in the circumstances reviewed by *Varig*, than the comparable obligation imposed and discretion available to the AEC in the present case. *Compare* 49 U.S.C. § 1421 (FAA safety duty) *with* 42 U.S.C. § 2051(d) (AEC safety duty). We cannot say that what was protected by the Supreme Court in *Varig* is now subject to liability.

Plaintiffs further contend that, even if the initial discretion granted the AEC by statute was broad, test site personnel violated the AEC's own policy directives by failing to implement adequate protective measures. We cannot accept this argument either. Neither the plaintiffs nor the district court have been able to point to a single instance in which test site personnel ignored or failed to implement specific procedures mandated by the AEC for monitoring and informing the public. Indeed, the district court's conclusions appear to be based, at least in part, on perceived inadequacies in the AEC's radiological safety and information plans themselves.[3] The court relied heavily on a 1964 report to the AEC by the Committee to Study Nevada Proving Grounds which was moderately critical of the measures taken up to that point to inform and warn the public. *See Allen*, 530 F.Supp. at 396–99, 402–03. The stated objective of this report, however, was "[t]o be a basis for Commission decisions on future policy." Pl.Ex. at 4. The operational plans the district court considered deficient embody these AEC policy decisions. As such, these plans clearly fall within the discretionary function exemption.[4]

Government liability cannot logically be predicated on the failure of test-site personnel to go beyond what the operational plans specifically required them to do. If, as the plaintiffs maintain, the AEC delegated "unfettered authority" to a Test Manager and his subordinates to implement public safety programs, this simply compels the conclusion that these officers exercised considerable discretion. Their actions, accordingly, also fall within the discretionary function exception.

[2, 3] It is irrelevant to the discretion issue whether the AEC or its employees were negligent in failing to adequately protect the public. *See Cleo v. United States*, 740 F.2d 788, 789 (7th Cir.1985); *General Public Utilities Corp. v. U.S.*, 746 F.2d 220, 243, 245 (3d Cir.1984), *cert. denied*, 469 U.S. 1228, 105 S.Ct. 1227, 84

3. The district court stated that its review of "the various radiation safety plans, public information plans, and related documents" disclosed the "astounding fact" that no concerted effort was made "to directly monitor and record internal contamination or dosage in off-site residents on a comprehensive person-specific basis." *Allen*, 530 F.Supp. at 373–74.

4. In the one instance which suggested that a subordinate contradicted an official directive by a superior, the district court quoted at length from a document which is characterized as a modification or redetermination of AEC policy regarding off-site exposure levels by personnel at the "STS operational level." *Allen*, 530 F.Supp. at 395–96. But the district court was actually quoting from the official Operations Plan for the RANGER test series which had been annexed as an appendix to the final-facts Group's after-action report. Def. Ex. 60 at 60, 69.

L.Ed.2d 265 (1988).[4] When the conduct at issue involves the exercise of discretion by a government agency or employee, § 2680(a) preserves governmental immunity "whether or not the discretion involved be abused." For better or worse, plaintiffs here "obtain their 'right to sue from Congress [and] necessarily must take it subject to such restrictions as have been imposed.'" *Dalehite v. United States*, 346 U.S. 15, 31, 73 S.Ct. 956, 965, 97 L.Ed. 1427 (1953) (quoting *Federal Housing Administration v. Burr*, 309 U.S. 242, 251, 60 S.Ct. 488, 493, 84 L.Ed. 724 (1940)).[5]

To be sure, the circumstances in *Varig* are not identical to those now before us. Most notably, *Varig* involved the actions of a regulatory agency supervising private individuals. The Court observed in *Varig* that the discretionary actions of government regulators were at the core of what § 2680(a) was intended to protect. But *Varig* expressly reaffirmed the earlier Supreme Court decision of *Dalehite v. United States*, 346 U.S. 15, 73 S.Ct. 956, 97 L.Ed. 1427 (1953), which found very broad governmental immunity outside a regulatory setting. *See Varig*, 467 U.S. at 810–14, 104 S.Ct. at 2762–64.

In *Dalehite*, private plaintiffs sued the government over deaths, injuries, and property damage resulting from a disastrous explosion of two shiploads of ammonium nitrate fertilizer. 346 U.S. at 22–23, 73 S.Ct. at 961. As with the AEC bomb-testing program before us here, Congress and the President, in response to international tensions following World War II, had decided on a crash government program—in *Dalehite*, a program to feed the populations of Korea, Japan, and Germany. *Id.* at 19–20, 73 S.Ct. at 959–60. Broad general authority was given to the War Department, and the War Department created a plan for massive fertilizer shipments. The Army's Chief of Ordnance was delegated discretionary responsibilities for carrying out the War Department plan, and he in turn appointed a "Field Director of Ammonition Plants" to administer the program. *Id.* Other lower-level plant managers and supply officers were also appointed.

As with the AEC bomb tests, the production of fertilizer in *Dalehite* involved a mix of private and public facilities and employees. *Id.* at 20–21, 73 S.Ct. at 960. As with the AEC bomb tests, all plans for manufacture, packing, and shipping of the fertilizer in *Dalehite* were officially approved. *Id.* at 38–40, 73 S.Ct. at 969–70. The *Dalehite* plaintiffs, like the present plaintiffs, were unable to point to any instance in which government employees acted negligently in performing specific, mandatory duties. The *Dalehite* plaintiffs instead argued primarily, just as the present plaintiffs argue here, that at various points the government could have made better plans, and that the government failed to fully investigate the hazards of the dangerous material involved and to fully inform and warn the nearby populace. *Id.* at 23, 73 S.Ct. at 961.

The Supreme Court in *Dalehite* found every contested government decision, action, and omission to be the performance of a discretionary function, exempt from suit under § 2680(a): the cabinet-level decision to export the fertilizer, the lower-level failure to fully test for explosive properties, the Field Director's fertilizer production plan, the actual production of the fertilizer in accordance with the government specifications, and the specific decisions to bag the fertilizer at a certain temperature and to label the fertilizer in a certain way. *Id.* at 24, 36–42, 73 S.Ct. at 962, 969–71. The various actions and omissions of the Coast Guard, supervising the actual loading of the ships, were also exempted, as was the general failure to warn the nearby populace of potential dangers. *Id.* at 25–26, 68, 73 S.Ct. at 961–62, 971.[7]

In *Varig*, the Supreme Court approved the view of § 2680(a) expressed in *Dalehite*, strongly rejecting any suggestion that later cases had narrowed the broad immunity found there. *Varig*, 467 U.S. at 810–14, 104 S.Ct. at 2762–64. Given the Court's holding in *Dalehite*, reaffirmed in *Varig*, we must conclude that the government is immune from liability for the failure of the AEC administrators and employees to monitor radioactivity more extensively or to warn the public more fully than they did.[8]

3. It is also irrelevant whether the alleged failure to warn was a matter of "deliberate choice," or a mere oversight. *See Allen*, 588 F.Supp. at 337–38. We agree with the treatment of this distinction in *Myslakowski v. United States*, 806 F.2d 94 (6th Cir.1986), *cert. denied*, — U.S. —, 107 S.Ct. 1688, 94 L.Ed.2d 793 (1987):

> "The critical error in the trial court's analysis is in its conclusion that because the evidence does not show that the departmental policymakers evaluated the pros and cons of requiring that a warning be given concerning the rollover propensity of the jeep and then made a discretionary decision not to give such warnings, it therefore follows that no discretionary decision, of the kind contemplated by § 2680(a), was made . . .
>
> Stated otherwise, even the negligent failure of a discretionary government policymaker to consider all relevant aspects of a subject matter under consideration does not vitiate the discretionary character of the decision that is made.
>
> Indeed, it is, in part, to provide immunity against liability for the consequences of negligent failure to consider the relevant, even critical, matters in discretionary decision-making that the statutory exception exists. If it were otherwise, a judgment based policy determination made at the highest levels, to which all would concede that the statutory exception applies (the decision to sell surplus jeeps), would result in an immunity if the decision could be shown to have been made without consideration of important, relevant factors, or was a decision negligently reached. If that reasoning were sound, the discretionary function exception would be inapplicable in every case in which a negligent 'failure to consider' a relevant risk could be proved."

Id. at 97–98. *Accord In re Consolidated United States Atmospheric Testing Litigation*, 616 F.Supp. 759, 776–77 (N.D.Cal.), *appeal docketed*, No. 85-2042 (9th Cir.1985).

6. Plaintiffs rely heavily upon an AEC policy report accepting responsibility for reimbursing radiation-caused losses. We cannot treat such an agency statement as waiving the "discretionary function" exclusion Congress placed in the FTCA. The existence of an administrative claims system does not constitute a waiver of sovereign immunity. *See United States v. Shearer*, 473 U.S. 52, 58 n. 4, 105 S.Ct. 3039, 3043 n. 4, 87 L.Ed.2d 38 (1985); *Feres v. United States*, 340 U.S. 135, 146–47, 71 S.Ct. 153, 158, 95 L.Ed. 152 (1950).

7. The Court in *Dalehite* approved a series of earlier lower court interpretations of § 2680(a), which the Court stated were generally "in conformity with our holding." *Dalehite*, 346 U.S. at 30 n. 32, 73 S.Ct. at 966 n. 32. The cited cases demonstrate the Court's intent in *Dalehite* to include extremely low-level and mundane decisions and conclusions of decisions within the discretionary function exception of § 2680(a). *See, e.g., Toledo v. United States*, 95 F.Supp. 830, 839, 845 (D.P.R.1951) (suit over car damage caused by tree at government facility falling on car, court holds that § 2680(a) bars recovery for failure to remove diseased experimental tree, but notes that negligent removal of tree might not be exempt); *Olsen v. United States*, 93 F.Supp. 150, 152–53 (D.N.D.1950) (suit for property damage caused by questionable discretionary decision of government employees to release flood waters from dam, court holds that § 2680(a) bars recovery).

8. We have previously followed the command of the Supreme Court in *Varig*. *See Russell v. United States*, 765 F.2d 780, 787 (10th Cir.1985) (no government FTCA liability possible, for failure of federal mine inspectors to more fully inspect Utah coal mine). Most of the post-*Varig* decisions of the other circuits are in accord with our holding today. *See, e.g., Myslakowski v. United States*, 806 F.2d 94, 97–99 (6th Cir.1986) (no liability for Postal Service decision to sell used jeeps, without warning buyers of jeep proneness to tip over), *cert. denied*, — U.S. —, 107 S.Ct. 1688, 94 L.Ed.2d 793 (1987); *Ford v. American Motors Corp.*, 770 F.2d 485, 486–88 (5th Cir.1985) (same); *Smith v. Johns-Manville Corp.*, 795 F.2d 301, 306–09 (3d Cir.1986) (no liability for GSA decision to sell asbestos without warning of hazards); *Merklin v. United States*, 788 F.2d 172, 174–75 (3d Cir.1986) (no liability for AEC inspectors' failure to warn uranium processing plant employees of health hazards discovered during AEC inspections); *Chevo v. United States*, 769 F.2d 716, 718 (11th Cir.1985) (no liability for FBI decision to obtain release of particular person from prison to use as informant); *Begay v. United States*, 768 F.2d 1079, 1086 (9th Cir.1985) (no liability for U.S. Public Health Service failure to warn uranium miners of radiation hazards); *Cisco v. United States*, 768 F.2d 708, 709–10 (7th Cir.1985) (no liability for EPA failure to warn residents of landfill dirt contaminated with dioxin); *Baxley v. United States*, 767 F.2d 1095, 1097–98 (4th Cir.1985) (no liability for FAA failure to regulate "ultralight" aircraft); *Shuman v. United States*, 765 F.2d 283, 291 (1st Cir.1985) (no liability for Navy failure to warn shipyard workers of asbestos hazards); *Hyde v. United States*, 755 F.2d 551, 554 (7th Cir.1985) (no liability for federal mine inspectors' failure to fully inspect clay mine); *Fayers v. United States*, 749 F.2d 1222, 1227 (6th Cir.1984) (no liability for Army's failure to inspect Chrysler's operations of government-owned railyard), *cert. denied*, 471 U.S. 1125, 105 S.Ct. 2655, 86 L.Ed.2d 273 (1985); *General Public Utilities Corp. v. United States*, 745 F.2d 239, 247 (3d Cir.1984) (no liability for Nuclear Regulatory Commission's failure to warn of possible equipment defects at the Three Mile Island nuclear facility), *cert. denied*, 469 U.S. 1220, 105 S.Ct. 1227, 84 L.Ed.2d 365 (1985); *Florentia v. United States*, 739 F.2d 202, 204 (5th

In the instant case, no evidence was presented of any act or omission of the AEC or its employees that clearly contravened a specific statutory or regulatory duty, or that exceeded statutory or regulatory authority. There was no evidence, for example, that the Test Information Officer failed to release information he was required to give out, or that the Radsafe Officer failed to take a specific radiation measurement that had been decided upon. Plaintiffs' entire case rests on the fact that the government *could* have made better plans. This is probably correct, but it is insufficient for FTCA liability.

Our decision here adheres to the principle enunciated by the Supreme Court of broad sovereign immunity. An inevitable consequence of that sovereign immunity is that the United States may escape legal responsibility for injuries that would be compensible if caused by a private party. There remain administrative and legislative remedies; we note the express authorization under 42 U.S.C. § 2012(i) for the government to make funds available for damages suffered by the public from nuclear incidents. Nonetheless, judicial reluctance to recognize the sometimes harsh principle of sovereign immunity explains much of the tangle of the prior FTCA cases.

The Court stated in *Varig* that the purpose of § 2680(a) was to avoid any judicial intervention that "would require the courts to 'second-guess' the political, social, and economic judgments of an agency." 467 U.S. at 814, 104 S.Ct. at 2764. The bomb-testing decisions made by the President, the AEC, and all those to whom they were authorized to delegate authority in the 1950s and 1960s, were among the most significant and controversial choices made during that period. The government deliberations prior to these decisions expressly balanced public safety against what was felt to be a national necessity, in light of national and international security. However erroneous or misguided these deliberations may seem today, it is not the place of the judicial branch to now question them.

For the above reasons, we find all challenged actions surrounding the government atomic bomb tests in the 1950s and 1960s to be immune from suit, as the performance by a federal agency of a "discretionary function," protected by § 2680(a).

We REVERSE the district court's decision with regard to those nine claims in which the government was found to have liability and REMAND for further proceedings consistent with this opinion.

McKAY, Circuit Judge, concurring:

It undoubtedly will come as a surprise to many that two hundred years after we threw out King George III, the rule that "the king can do no wrong" still prevails at the federal level in all but the most trivial of matters. After the passage of the Federal Tort Claims Act, 28 U.S.C. §§ 2671–2680 (1962) (FTCA), many people, as well as the lower federal courts, assumed that the old governmental immunity from responsibility for negligent conduct that injures individual citizens was gone. Many endorsed what appeared to be the FTCA's policy that if the citizens at large benefited from a government program, that collective citizenry, not the isolated individual injured by the negligent conduct of the program, would bear the economic burden of that injury. This case dramatically illustrates that, as interpreted by the Supreme Court in *United States v. S.A. Empresa de Viacao Aerea Rio Grandense (Varig Airlines)*, 467 U.S. 797, 104 S.Ct. 2755, 81 L.Ed.2d 660 (1984), the FTCA (and for that matter Congress' injunction that a program be carried out safely) is largely a false promise in all but "fender benders" and perhaps some cases involving medical malpractice by government doctors.

When Congress decided to employ above-ground testing, it repeatedly evinced the general intent that the tests should be conducted so as not to jeopardize the health and safety of the population downwind.[1] However, it did not delineate the health and safety measures to be taken. No mention is made of how fallout from open-air testings should be monitored or how the public should be educated regarding the effects of fallout—the two issues litigated in this case. The responsibility for developing defined health and safety plans and for disseminating information was instead delegated to the AEC.

Based on ample evidence, the trial court found that the people who designed the downwind safety program deviated from optimum practices based on the best available scientific knowledge. On a fully supported record, the trial court found the following deviations in the plans which would clearly support liability for injury under standard tort analysis as applied by the trial court: the decision to monitor randomly rather than on a "comprehensive, person-specific basis," *Allen v. United States*, 588 F.Supp. 247, 374 (D.Utah 1984); decisions not to use thyroid or whole body counters, *id.* at 375; decisions regarding the limited extent of urine, fecal, and blood sampling, *id.* at 374; the decision not to test milk samples "in order to avoid arousing public concern," *id.* at 375; the decisions to forego internal fallout assessment from inhalation of fallout particles, *id.* at 376; decisions regarding the extent of follow-up monitoring in downwind communities, *id.* at 379; the decision to distribute film badges and pocket dosimeters to a select number of residents rather than to every resident, *id.* at 379–81, 384–85; the decisions regarding duration of monitoring, *id.* at 381; the decisions with respect to the quantum of personnel and equipment committed to the monitoring program, *id.* at 381–82; and the decisions concerning the content and appropriate tone of the information given the public as well as the decisions to use pamphlets and films as the education media, *id.* at 385–404.

Again, on a fully supported record, the trial court found that these departures from accepted safety standards were the proximate cause of suffering and death from cancer in many of the plaintiffs. Under the then-available legal precedents, the trial court reasonably concluded that the FTCA showed Congress' intent that the Government, which benefited from the testing, should bear these particular costs. The critical analysis dealt with Congress' decision in the FTCA to exempt from liability those government acts broadly and vaguely described as "discretionary functions." *See* 28 U.S.C. § 2680(a).

At the time of the trial court's decision, the leading construction of that provision by the Supreme Court was *Dalehite v. United States*, 346 U.S. 15, 73 S.Ct. 956, 97 L.Ed. 1427 (1953). Language in *Dalehite* invited some courts to focus on the bureaucratic level of the decision maker in determining whether the ensuing decision or action was clothed with immunity under the discretionary function exception. Cabinet-level actions were considered clearly of a "planning" nature and thus immune. A vehicular collision resulting from driver negligence involved "operational" action and was not immune. *See Dalehite*, 346 U.S. at 28, 37, 73 S.Ct. at 964, 969. Struggling to give meaning to the elusive terms "discretionary function," and noting particularly the subsequent decisions of the Supreme Court in *Rayonier Inc. v. United States*, 352 U.S. 315, 77 S.Ct. 374, 1 L.Ed.2d 354 (1957), and *Indian Towing Co. v. United States*, 350 U.S. 61, 76 S.Ct. 122, 100 L.Ed. 48 (1955), some courts thought

Cir.1984) (no liability for INS's "specific operational decision" to permit a Cuban refugee known to be a convicted felon to enter the United States). *But see Aslakson v. United States*, 790 F.2d 688, 691–94 (8th Cir.1986) (FTCA liability possible for government agency's failure to comply with its own already established safety policy); *Henderson v. United States*, 784 F.2d 942, 943 n. 2 (9th Cir.1986) (FTCA liability possible, for government missile facility safety decision not made "at the planning stage," but "operational in nature"); *Collins v. United States*, 783 F.2d 1225, 1228–31 (5th Cir.1986) (FTCA liability possible, for failure of Mine Safety and Health Administration to close mine, when challenged decisions of subordinates did not involve "policy" decisions, or involved only explicit mandatory duties); *Alabama Electric Cooperative v. United States*, 769 F.2d 1573, 1526–29 (11th Cir.1985) (FTCA liability possible, for "operational" decisions of Army Corps of Engineers in constructing river dikes).

1. *See* The Atomic Energy Act of 1946, ch. 724, 60 Stat. 755 and The Atomic Energy Act of 1954, ch. 1073, 68 Stat. 921 (codified as amended at 42 U.S.C. §§ 2011–2296 (1982 & Supp. III 1985)).

For detailed discussion of the two act's safety provisions, see *Allen v. United States*, 588 F.Supp. 247, 348–50 (D.Utah 1984).

the Supreme Court intended to narrow the sweep of its *Dalehite* interpretation of that exception. *See, e.g., Relf v. United States*, 433 F.Supp. 423, 427 (D.D.C.1977), *aff'd*, 593 F.2d 1371 (D.C.Cir.1979). Following that pattern, the trial court in this case focused on the decisions made at the operational level. It concluded they were not immune.

Since the appeal was lodged in this case, the Supreme Court decided *Varig Airlines*. That opinion removed all doubt as to whether the discretionary function exception is to be construed broadly or narrowly. In *Varig* the Court explicitly denounced both the increasingly narrow construction given the exception since *Dalehite* and the interpretation of *Dalehite* that focused on the bureaucratic level of the decision maker. The Court stated, "[I]t is the nature of the conduct, rather than the status of the actor, that governs whether the discretionary function applies in a given case." *Varig Airlines*, 467 U.S. at 813, 104 S.Ct. at 2764. It breathed vitality into *Dalehite* by selectively quoting language other than the planning/operational language most often cited previously: "Where there is room for policy judgment and decision there is discretion." *Id.* at 811, 104 S.Ct. at 2763 (quoting *Dalehite*, 346 U.S. at 36, 73 S.Ct. at 968). The Court thus shifted the discretionary function inquiry back toward examining the nature and character of the governmental action to determine whether it is of the type intended to be protected from tort liability by Congress. Those decisions "grounded in social, economic, and political policy," *id.* at 814, 104 S.Ct. at 2764, are insulated from our review, regardless of who the decision maker happens to be or how negligent the decision or action may be.

The majority opinion fully deals with the Supreme Court's focus in *Varig Airlines*. It is sufficient here to note that the focus is on the nature of the planning or decision making rather than on the level at which that planning or its implementation takes place. While that may create analytical problems even in automobile accident cases where the driver is left to "plan" how to drive and carry out his mission in the most economic fashion, both the facts and language of *Varig* easily cover the facts of this case. *Varig* involved an allegedly faulty safety inspection program for aircraft. The factual parallel to the safety programs at issue here cannot be distinguished on a principled basis. *Varig Airlines* gives little help to lower courts applying the new standard to specific facts—if the FTCA waiver of immunity indeed applies to anything but trivial government failures, such as automobile accidents. Nonetheless, it removes all doubt that the discretionary function exception swallows the negligent decisions before us.

The AEC devised safety and information plans prior to every open-air detonation, tailoring the plans to the demands of each specific project. None of the trial court's documented list of failures represents an instance of deviation from, or negligent implementation of, the safety and information plans adopted.[2] Rather, the court's extensive criticisms and ultimate conclusions of negligence were directed at the substance and failures of the plans themselves.

On appeal, plaintiffs do assert that "the evidence clearly demonstrates negligent and wrongful *failure to execute* and *deviation from* ... the plans approved by the Commission." Brief for the Appellee at 22 (emphasis in original). However, the evidence does not support this allegation.

2. If the evidence had demonstrated such deviation or negligent implementation, neither *Varig Airlines* nor *Dalehite* would bar our review. Both those cases confirm that *conformity* to a discretionary plan insulates the governmental action from review. *See Dalehite*, 346 U.S. at 36, 73 S.Ct. at 968 ("It necessarily follows that acts of subordinates in carrying out the operations of government in accordance with official directions cannot be actionable."); *Varig Airlines*, 467 U.S. at 820, 104 S.Ct. at 2767 (acts of FAA employees immune from review because dictated by immune policy-based program). *Deviation* from an immune plan or negligent implementation of an immune plan, however, can strip the action of the discretionary function exception, for such governmental action does not involve the type of social, economic, or political policy considerations at the core of the exception.

Not one example is given of a failure to monitor or distribute information *as prescribed in the plans*.[3] Rather, plaintiffs' challenge, mirroring the trial court's concerns, goes toward the failure of the plans to specifically prescribe greater monitoring or more diffuse and in-depth information distribution. Plaintiffs' statement that "test site personnel negligently and wrongfully failed to implement basic radiological protection measures *which were common at the time*," *id.* at 24 (emphasis added), demonstrates the true character of their allegations. Plaintiffs concede as much by stating that the trial court "determined that the fallout monitoring *program* and information *program* which coincided with the 1951-1962 open-air testing at the Nevada test site *did not comport with the 'best available scientific knowledge.'*" *Id.* at 42-43 (emphasis added).

In arguing that the safety and information plans themselves are not immune from our review under the discretionary function exception, plaintiffs contend:

> Where Congress has placed a mandatory duty upon the government to protect public health and safety, such as it did upon the Commission, it left no room for further policy-making regarding public safety. Where there is not policy-making there is no "discretion" within the meaning of 28 U.S.C. § 2680(a) and no immunity.

Id. at 13. Essentially, they assert that because the two Atomic Energy Acts demonstrate a concern for public health and safety, even though no specific health and safety measures are mandated therein, the safety plans devised to address that concern involved no social, economic, or political policy making.

On the contrary, the broad safety language of the Atomic Energy Acts had to be translated into concrete plans, and that translation involved the very essence of social, economic, and political decision making—the precise policy choices protected by the discretionary function exception. *See General Pub. Util. Corp. v. United States*, 745 F.2d 239, 244 (3d Cir.1984) (means chosen by Nuclear Regulatory Commission to fulfill its broad statutory duty to review safety of nuclear facilities protected by discretionary function exception), *cert. denied*, 469 U.S. 1228, 105 S.Ct. 1227, 84 L.Ed.2d 365 (1985). These decisions concerned choices involving the social psychology of how best to inform without alarming residents, the most cost-effective way of using public funds to monitor fallout levels, and how best to use a finite number of personnel. In short, they required the AEC "to establish priorities for the accomplishment of its policy objectives by balancing the objectives sought to be obtained against such practical considerations as staffing and funding." *Varig Airlines*, 467 U.S. at 820, 104 S.Ct. at 2767. While those choices deviated from the standards against which liability is measured where liability is available, Congress' determination to retain government immunity for "discretionary functions," as understood post-*Varig Airlines*, puts those choices beyond our ability to review and puts compensation for injury to individuals stemming from those choices beyond our power to order.

While we have great sympathy for the individual cancer victims who have borne alone the costs of the AEC's choices, their plight is a matter for Congress. Only Congress has the constitutional power to decide whether all costs of government activity will be borne by all the beneficiaries or will continue to be unfairly apportioned, as in this case. Until Congress amends the discretionary function exception to the FTCA or passes a specific relief bill for individual victims, we have no choice but to leave them uncompensated. I must therefore concur in the majority opinion which

3. At one point in their brief, plaintiffs state that the test manager "authorized [the radsafety] officers to go beyond the information radsafety plans." Brief for the Appellee at 57. In other words, the test manager authorized the officers to deviate from the plan. Plaintiff argues that because the officers were so authorized, their failure to deviate from the plan subjects the Government to liability. This reasoning is at direct odds with *Varig Airlines* and *Dalehite*. *See supra* note 2. It is just such deviation from a discretionary plan that can deprive the action of the protection of the discretionary function exception.

has carefully reviewed and applied the controlling law to the facts of this case.

UNITED STATES of America,
Plaintiff-Appellee,

v.

Patrick Henry EARLEY,
Defendant-Appellant.

No. 85-2472.

United States Court of Appeals,
Tenth Circuit.

April 21, 1987.

Defendant was convicted of two counts of distributing controlled substances by the United States District Court, Western District of Oklahoma, Ralph G. Thompson, Chief Judge, which subsequently issued order, sua sponte, "clarifying" that sentences imposed on narcotics violations were to run consecutively with previously imposed federal sentence. Defendant appealed. The Court of Appeals, Logan, Circuit Judge, held that: (1) federal sentences imposed for defendant's narcotics violations were presumed to run concurrently with previously imposed federal sentence, and (2) district judge could not, consistent with double jeopardy clause, issue his "clarifying" order after defendant had already begun to serve narcotics sentences five months earlier.

Reversed.

McKay, Circuit Judge, concurred in result and filed opinion.

Stephen H. Anderson, Circuit Judge, dissented and filed opinion, in which Barrett, Circuit Judge, joined.

1. Criminal Law ⇐996(1.1)

Sentence that is internally ambiguous or self-contradictory to point that reasonable person cannot determine what sentence was imposed may be found "illegal," for purpose of rule of criminal procedure allowing district court to correct "illegal" sentence at any time. Fed.Rules Cr.Proc. Rule 35(a), 18 U.S.C.A.

See publication Words and Phrases for other judicial constructions and definitions.

2. Criminal Law ⇐991(1.5), 996(1.1)

Federal sentences imposed for defendant's narcotics violations were presumed to run concurrently with previously imposed federal sentence, pursuant to which defendant was reincarcerated as parole violator, where district court's oral pronouncement and written judgment and commitment order said nothing about whether new sentences ran concurrently with or consecutively to sentence defendant was already serving, and there was no evidence in record to suggest that defendant or his counsel was aware that court intended sentences to run consecutively; under the circumstances, there was no fatal ambiguity in new sentences which would render them "illegal" and subject to correction by district court. Fed.Rules Cr.Proc.Rule 35(a), 18 U.S.C.A.

3. Criminal Law ⇐996(1.2)

Rules of criminal procedure, authorizing district court to correct "clerical mistakes" at any time, did not authorize judge to issue order "clarifying" that sentences for defendant's narcotics convictions were to run consecutively with previously imposed federal sentence, where there was no contention that clerical error was made. Fed.Rules Cr.Proc.Rule 36, 18 U.S.C.A.

See publication Words and Phrases for other judicial constructions and definitions.

4. Criminal Law ⇐189

Unless statute or rule extends sentencing process further, sentencing judge cannot, consistent with double jeopardy clause, enhance defendant's sentence after defendant has moved from jurisdiction of court into executive custody. U.S.C.A. Const. Amend. 5.

5. Criminal Law ⇐189

District court could not, consistent with double jeopardy clause, issue order providing that defendant's narcotics sentences were to run consecutively with previously imposed federal sentence, where there was nothing in judge's oral pronouncement or written judgment and commitment order indicating that new sentences were to run consecutively with previous sentence, and where defendant had already begun to serve sentence nearly five months before district court attempted to issue such order. U.S.C.A. Const.Amend. 5.

James W. Berry of James W. Bill Berry & Associates, Oklahoma City, Okl., for defendant-appellant.

Arlene Joplin, Asst. U.S. Atty. (William S. Price, U.S. Atty., and Karla McAlister, Asst. U.S. Atty., on the briefs), Oklahoma City, Okl., for plaintiff-appellee.

Before HOLLOWAY, Chief Judge, BARRETT, McKAY, LOGAN, SEYMOUR, ANDERSON, TACHA, and BALDOCK, Circuit Judges.

ON REHEARING EN BANC

LOGAN, Circuit Judge.

The only issue in this appeal is whether a federal district judge who failed to state whether sentences he imposed were consecutive to or concurrent with a preexisting federal sentence may order, five months later and after the defendant was imprisoned, that the sentences were to be consecutive. The district judge described his later order as a "clarification . . . to eliminate any ambiguity as to the Court's intention." R. I, 41.

Defendant, Patrick Henry Earley, was indicted on five counts and pleaded guilty in November 1984 to two counts of distributing controlled substances, offenses he committed in 1982 while on parole from a twenty-five-year federal sentence. Because of these offenses, Earley had been reincarcerated as a parole violator since 1982 on his earlier sentence; the parole board had specified a tentative re-release date of January 7, 1985.

On January 4, 1985, the district court conducted its sentencing hearing on the offenses at issue here. During the sentencing hearing the court commented that Earley had limited his exposure very substantially by his plea bargain, and declared that because Earley had shown a succession of criminal activity over time, the court saw no reason to credit him with any reduction of time beyond the plea bargain.[1] But the court did not state whether the

1. The entire commentary by the district court was as follows:

"THE COURT: Mr. Earley's pre-sentence report is one of the more remarkable ones that I have reviewed in nine years plus of attempting to find fair and appropriate sentences in criminal cases. It is one of the most serious and extensive criminal records that I have seen. I know nothing about Mr. Earley other than what I read in the report and what I have heard from what's been said in this proceeding.

But, it does strike me that from an early age and throughout his lifetime, there has been just a succession of criminal activity that gives me absolutely no basis for expecting or hoping for any kind of rehabilitation in the case.

Ordinarily, and in any criminal case, a plea of guilty itself gives the sentencing judge some basis for positive expectations in regard to the Defendant. There is hardly any basis for that in this case.

Mr. Earley has certainly made a very favorable plea bargain, however, and severely limited his total exposure to punishment as a result of the favorable plea agreement. And, there's nothing wrong with that, it is encouraged and it's perfectly legitimate. In doing so, he has limited his exposure very substantially and has the benefit of having done so. But, beyond that, there is simply no reason that I can find to credit Mr. Earley with any reduction in time. His probation violation argument is not persuasive in light of the fact that he has actually just been required to serve out the punishment for another offense. All he had to do to avoid that was not break the law. And, he saw fit to engage in narcotics trafficking, which is a very serious offense. And, under all these circumstances, I simply find that he gets the benefit of his plea agreement. But there is no basis for any other consideration.

And, accordingly, it is the judgment of the Court that on each of Counts 1 and 3, the Defendant is committed to the custody of the Attorney General, or his authorized representative, for imprisonment for a term of five years to run consecutively for a total of ten years, and to serve a special parole term of life.

EXHIBIT D

96th Congress
2d Session

COMMITTEE PRINT

COMMITTEE PRINT 96-IFC 53

"THE FORGOTTEN GUINEA PIGS"

A REPORT ON HEALTH EFFECTS OF LOW-LEVEL RADIATION SUSTAINED AS A RESULT OF THE NUCLEAR WEAPONS TESTING PROGRAM CONDUCTED BY THE UNITED STATES GOVERNMENT

REPORT

PREPARED FOR THE USE OF THE

COMMITTEE ON
INTERSTATE AND FOREIGN COMMERCE
UNITED STATES HOUSE OF REPRESENTATIVES

AND ITS

SUBCOMMITTEE ON OVERSIGHT AND
INVESTIGATIONS

AUGUST 1980

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LETTER OF TRANSMITTAL

CONGRESS OF THE UNITED STATES
HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON OVERSIGHT AND INVESTIGATIONS
OF THE
COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE
WASHINGTON, D.C. 20515

August 7, 1980

Honorable Harley O. Staggers
Chairman
Interstate and Foreign Commerce
Committee
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Over the past year, the Subcommittee on Oversight and Investigations held four days of hearings and reviewed extensive scientific data to examine the consequences of the nuclear tests carried on at the Nevada Test Site during the 1950's and 1960's. The two overriding issues before the Subcommittee related to the government's responsibility (1) for assuring the health and safety of its people and the integrity of the environment when testing nuclear weapons, and (2) for compensating any injured party and restoring the environment when harm has occurred as a consequence of the government's action.

Upon review of the data, the Subcommittee found that while the government was aware of the health hazards posed to the people living downwind from the test site, the government failed to provide adequate protection for the residents of this area during its operation of the nuclear weapons testing program. At the very least, the government owed these people a responsibility to inform them of the exact time and place of each test and the necessary precautions that should have been taken to protect their health and safety. Absent such notification, and uninformed of the evidence held by the government which suggested that exposure to nuclear fallout was causing harmful effects, the residents of this area merely became guinea pigs in a deadly experiment.

Sheep ranchers in the area lost some 4,400 sheep during the spring and summer of 1953, at the time that the "Upshot-Knothole" nuclear test series was being conducted at the test site. Despite evidence indicating a causal relationship between the sheep deaths and exposure to nuclear fallout, the Subcommittee found that these sheep ranchers remain uncompensated to this day because of the government's suppression and disregard of such data in the official investigation and reporting of the matter and, finally, in the

litigation of the case before the Utah District Court in 1956.

Still further, scientific data presented to the Subcommittee revealed that an unusual increase in leukemia deaths occurred in southwestern Utah for the years 1959-1960; additional leukemia "hot spots" were documented in Arizona and Utah for the years 1965-1970, and in Nevada for the years 1959-1963; and a twofold increase in thyroiditis and a fourfold increase in thyroid cancer occurred in Utah during the years 1948-1962. Witnesses before the Subcommittee detailed personal accounts of illnesses and deaths among family and friends which vividly painted a tragic picture of human suffering that has continued to the present day.

The Subcommittee found that the existing legal remedy available to claimants under the Federal Tort Claims Act is fraught with legal hurdles unique to radiation-related cases. Since the clinical features of radiogenic cancers are not distinguishable from the features of other cancers, it is virtually impossible to identify an individual with a radiation-induced cancer from the much larger class of individuals who will develop cancer from other causes. As a result, the nuclear radiation victims incur added burdens, in terms of time and expense, to pursue their claims against the government with no degree of certainty or predictability of their successful outcome.

The Subcommittee determined that sufficient evidence exists for the government to accept at least compassionate responsibility, if not strict legal liability, for the injuries sustained by the downwind residents as a result of the nuclear weapons testing program. Additionally, the Subcommittee found that the arduous, time-consuming, and expensive nature of any judicial resolution of the matter compels the Congress to develop a legislative solution.

In devising such a compensatory scheme, the Subcommittee recommends that the Congress define the class of eligible claimants by (a) the nature of the injury; (b) the residence of the eligible claimants; and (c) the time period and duration of such residence. To make further determinations respecting illnesses which may be appropriate for compensation, the Subcommittee proposed the establishment of an independent review panel. Finally, the Subcommittee recommends that the Federal Courts have jurisdiction over resolving the questions pertaining to eligibility and damages.

Upon determining the reason for the government's failure to provide adequate protection to the downwind residents, the Subcommittee concluded that a conflict within the authority to regulate nuclear energy existed in the Atomic Energy Commission such that the Commission's decisions were weighted in favor of promoting the nuclear weapons testing program over controlling the safe production

and use of nuclear energy. Still further, the Subcommittee found that this conflict has continued to this day in the AEC's successor agencies--the Department of Energy, the Department of Defense, and the Nuclear Regulatory Commission. As the primary responsibility and funding authority for radiation health research remains within these agencies, a bias, or at the very least, an appearance of a bias, to promote nuclear technology exists in the results of this research without a corresponding concern for health and safety.

To address this inherent conflict in nuclear regulatory authority, the Subcommittee recommends that the agencies responsible for the protection of the health and welfare of the American people--including the Department of Health and Human Services, the Environmental Protection Agency and the Occupational Safety and Health Administration--be given the primary responsibility and funding authority to conduct radiation health research. Moreover, the Subcommittee proposes that the government undertake such health research to assist the independent review panel, and continue to support the research undertaken and proposed by the States of Utah, Nevada and Arizona.

The findings and recommendations in this report have been made by the Subcommittee in recognition that we, as a nation, must accept the consequences of our governmental decisions and properly and promptly compensate the victims of our mistakes. Moreover, we must learn from events such as these so that we do not repeat past mistakes to the detriment of the health and welfare of future generations.

In conclusion, I want to acknowledge the cooperation of Senator Kennedy's Subcommittee on Health and Scientific Research and Committee on the Judiciary with respect to our joint hearing in Salt Lake City, Utah, and to recognize Subcommittee staff Counsels, Peter Kinzler and Mary Foldes, for their contribution in the preparation of this report.

Sincerely,

Bob Eckhardt
Chairman
Subcommittee on
Oversight and Investigations

The skin conditions observed by the medical officers in most cases were typical of allergic dermatitis. . . . There were several cases of sunburn which the patients thought were due to radiation, but the size, distribution, and time sequence of events would not substantiate the diagnosis of nuclear radiation inflicted burns. Two types of eye conditions were seen. One was flash blindness, and the other was itching, lachrymation, and reddening of the conjunctiva over a prolonged period of time. . . . Other cases were those of people who just 'didn't feel well,' or who had generalized malaise, or cases of enteritis. In most cases it was sufficient for the medical officer to discuss the possible biological effects of radiation with them and they would realize that the symptoms which they had could not be due to fallout.[99]

In contrast to the U.S. Public Health Service documentation of exhibited, albeit discounted, radiation-related illnesses, the AEC advertized the "unusual safety record" set during the government's operation of the atmospheric nuclear testing program. The following excerpt from an AEC pamphlet (dated January 1, 1955) aptly characterizes the publicized view of the AEC:

Each Nevada test has successfully added to scientific knowledge needed for development and for use of atomic weapons and needed to strengthen our defense against enemy weapons. An unusual safety record has been set. No one inside the Nevada test site has been injured as a result of the 31 test detonations. No one outside the test site in the nearby region of potential exposure has been hurt. There were instances of property damage from blasts such as broken windows. Some cattle and horses grazing within a few miles of the detonations suffered skin radiation burns, but the damage had no effect on their breeding value nor the beef quality of the cattle.[100]

Commenting on the government's lack of candor with the American public, Utah Governor Scott Matheson testified that "an all-out public relations campaign was mounted by the Atomic Energy Commission to assure those who lived close to the test site that there [was] no danger." [101] Peter A. Libassi (former General Counsel for the Department of Health, Education and Welfare) also discussed the issue before the Subcommittee. Mr. Libassi testified that, despite the urgings of then-HEW Secretary Gardner to the White House for full disclosure of information, ". . . the press releases which were finally issued did not contain the information and warnings and concerns and questions that were already emerging." [102] Specifically with regard to the sheep, thyroid and leukemia studies, Mr. Libassi noted the suppression of the data by the Federal Government from public dissemination:

. . . the American people were not informed of the evidence that was gathered during the 1950's and 1960's of the uncertainty as to the health effects of radiation from these atmospheric nuclear tests. They were simply not informed of the uncertainties that we knew about at that time.[103]

5. Conclusions

Based on the evidence presented, the Subcommittee concludes that:

(1) the government, despite having sufficient reason to know of the hazards associated with radiation exposure, failed to give adequate warning to the residents living downwind from the test site regarding the dangers posed by the radioactive fallout emitted during the atmospheric nuclear test operations;

(2) the radiation monitoring system established by the government during the atmospheric nuclear testing program was deficient in giving

[99] Id. at 548.
[100] Joint Hearings, supra note 13, at 246.
[101] Id. at 16.
[102] Id. at 99.
[103] Id. at 100.

accurate estimates of radiation exposure necessary to provide adequate health protection to the downwind residents;

(3) the government falsely interpreted and reported radiation exposure rates so as to give an inaccurate estimate of the hazards posed to the downwind residents from the atmospheric radioactive fallout;

(4) the government knowingly disregarded evidence which questioned the accuracy of the government's measurements of radioactivity emitted from the test site as well as the adequacy of the then-employed radiological safety standards; and

(5) exposure to radioactive fallout emitted during the atmospheric nuclear test operations was, more likely than not, responsible for the serious adverse health effects suffered by the downwind residents.

Additionally, the Task Force discussed whether or not recovery under such a remedy should bar a downwind resident from filing a claim under the FTCA. While an exclusive approach would limit the financial liability of the government to such claimants, the Report advised that such an approach must insure a reasonable alternative through the litigation process in order to be held constitutional.[168] In sum, the Task Force concluded that an administrative compensation program "may well be the best mechanism for addressing the health issues arising from the atmospheric weapons testing program" insofar as "such a remedy could include eligibility criteria which would reflect current and future scientific knowledge of radiation effects, while at the same time providing a reasonable level of benefits."[169]

D. CONCLUSIONS

Based on the evidence presented, the Subcommittee concludes that:

(1) the existing legal remedy provided for under the Federal Tort Claims Act offers no degree of certainty or predictability regarding questions of causation which are unique to radiation-related illnesses;

(2) nuclear radiation victims should not bear any further burdens, particularly in terms of time and expense, which may be attendant to a judicial resolution of such claims;

(3) the government must accept responsibility, whether legal or moral, for the injuries sustained by individuals as a result of the government's operation of the nuclear weapons testing program; and

(4) a legislative remedy would provide the most adequate and expeditious means by which the government can accept and address such responsibility.

E. RECOMMENDATIONS

Based on the evidence presented to the Subcommittee and the conclusions reached therefrom, the Subcommittee recommends that:

(1) Congress should devise a legislative solution which would address and resolve the questions of causation for such nuclear radiation-related claims by defining the eligible claimants; the factors to be specified under the legislation should include: (a) the nature of the injury, (b) the residence of the eligible claimant, and (c) the time period and duration of such residence;

(2) an independent panel should be established to make further determinations respecting illnesses which may be appropriate for compensation under this legislation; and

(3) the Federal Courts should have jurisdiction over the questions of eligibility as well as the issues relative to the determination of damages for compensating nuclear radiation victims under this legislation.

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[168] Id. at 55.
[169] Id. at 56.

V. Summary Conclusion

Atmospheric testing of nuclear weapons in the 1950's and 1960's may well have been essential to secure the national defense. However, because the agency charged with developing nuclear weapons was more concerned with that goal than with its other mission of protecting the public from injury, the government totally failed to provide adequate protection for the residents of the area. There was sufficient information available from the beginning to suggest that if it was not possible to conduct the testing outside the continental United States, then the people living nearby needed protection. The necessary protection could have been provided by evacuating some of the people but, at a minimum, the government owed the residents a duty to inform them of the precise time and place of each test and to instruct them as to what precautions should be taken. In addition, the government's program for monitoring the health effects of the tests was inadequate and, more disturbingly, all evidence suggesting that radiation was having harmful effects, be it on the sheep or the people, was not only disregarded but actually suppressed.

The greatest irony of our atmospheric nuclear testing program is that the only victims of U.S. nuclear arms since World War II have been our own people.[179] The Subcommittee believes that legislation should be passed that provides prompt and adequate compensation for the victims of this program. In addition, the Subcommittee believes that similar problems can best be avoided in the future if the responsibility for protecting the people is given to an agency whose main mission is to assure public health, not to advance nuclear development.

[179] The Subcommittee includes within this context those individuals living in the trust territories of the Pacific Islands.

Senator HATCH. With that, we want to thank you again, and we'll recess our hearing.

Thank you.

[Whereupon, at 11:47 a.m., the committee was adjourned.]

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